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Nishizawa et al.

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(45) **Date of Patent: Jul. 5, 2016**

(54) **INTAKE NOISE REDUCTION DEVICE AND STRADDLE-TYPE VEHICLE INCLUDING THE SAME**

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(30) **Foreign Application Priority Data**

Jun. 3, 2014 (JP) 2014-114615

(51) **Int. Cl.**

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F02M 35/12	(2006.01)
F02M 35/02	(2006.01)
F02M 35/10	(2006.01)
B62M 7/04	(2006.01)
B62K 19/40	(2006.01)
F02M 35/16	(2006.01)
F02M 35/024	(2006.01)

(52) **U.S. Cl.**

CPC ***F02M 35/1255*** (2013.01); ***B62K 19/40*** (2013.01); ***B62M 7/04*** (2013.01); ***F02M 35/0201*** (2013.01); ***F02M 35/02425*** (2013.01); ***F02M 35/10118*** (2013.01); ***F02M 35/14*** (2013.01); ***F02M 35/162*** (2013.01)

(58) **Field of Classification Search**

CPC F02M 35/1255; F02M 35/1261; F02M 35/12; F02M 35/14; F02M 35/162

USPC 180/219

See application file for complete search history.

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Assistant Examiner — Michael Stabley

(74) *Attorney, Agent, or Firm* — Rabin & Berdo, P.C.

(57) **ABSTRACT**

An intake noise reduction device includes an air cleaner, an intake funnel and a resonator, and is connected to an engine via a throttle body. The resonator is provided inside of the air cleaner. The resonator includes a chamber portion and a pipe portion. The pipe portion is formed to extend downward from the chamber portion, and has an opening end at a lower end. The intake funnel is provided at a lower end of the air cleaner. An opening end of the resonator is inserted into the intake funnel. A cross sectional area of an intake passage between the intake funnel and the pipe portion is set to not less than an opening area of an intake passage of the throttle body opened to a maximum throttle opening.

8 Claims, 24 Drawing Sheets

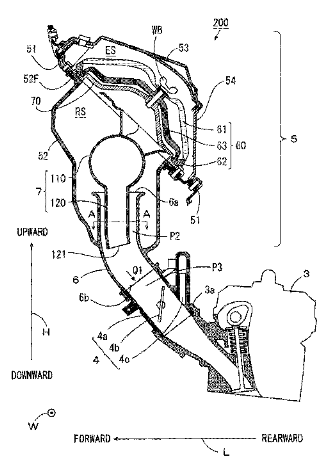
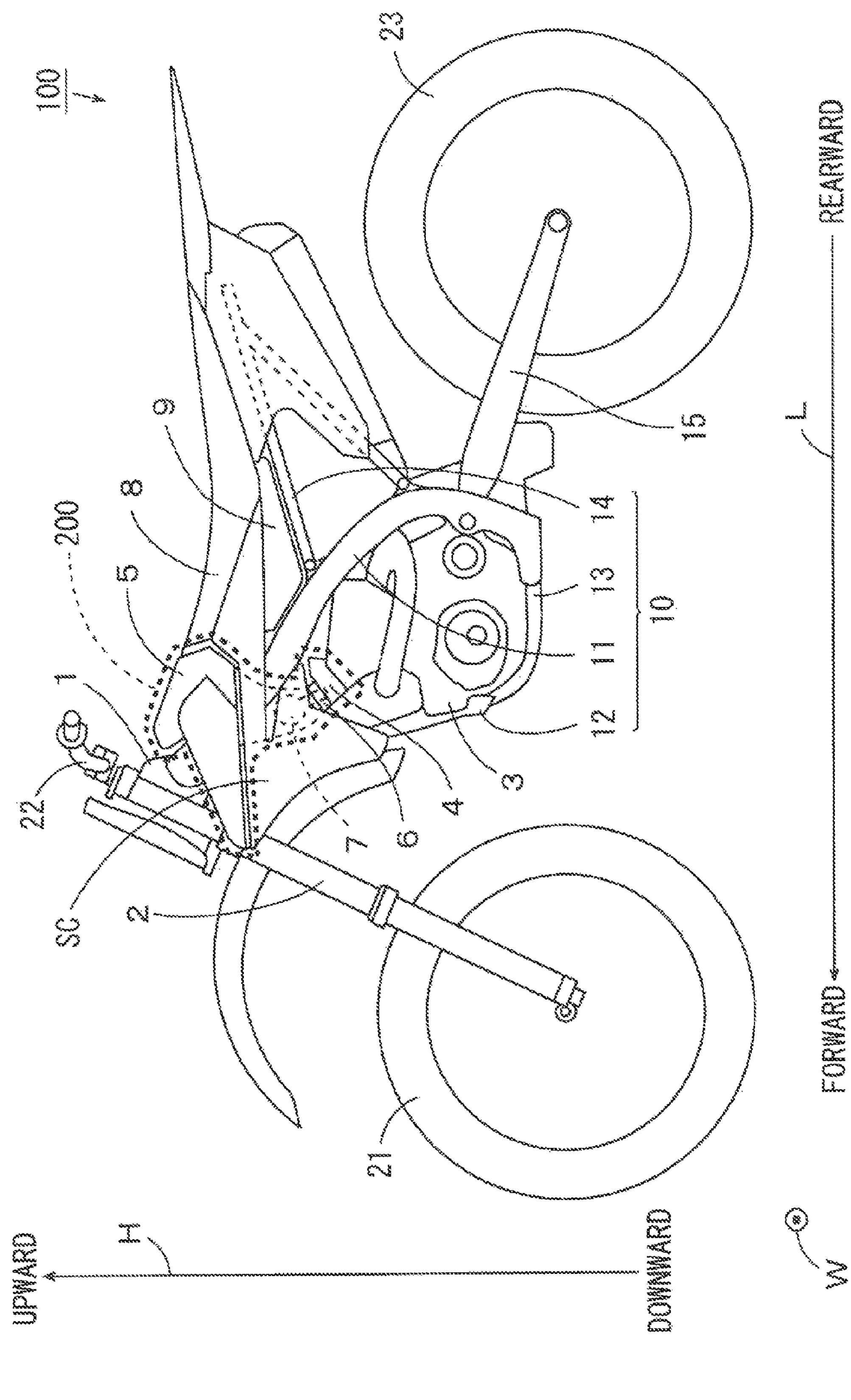


FIG. 1


100
23
REARWARD
9
8
200
5
1
22
SC
2
7
6
4
3
12
11
13
14
10
15
L
FORWARD
21
H
UPWARD
DOWNWARD
W

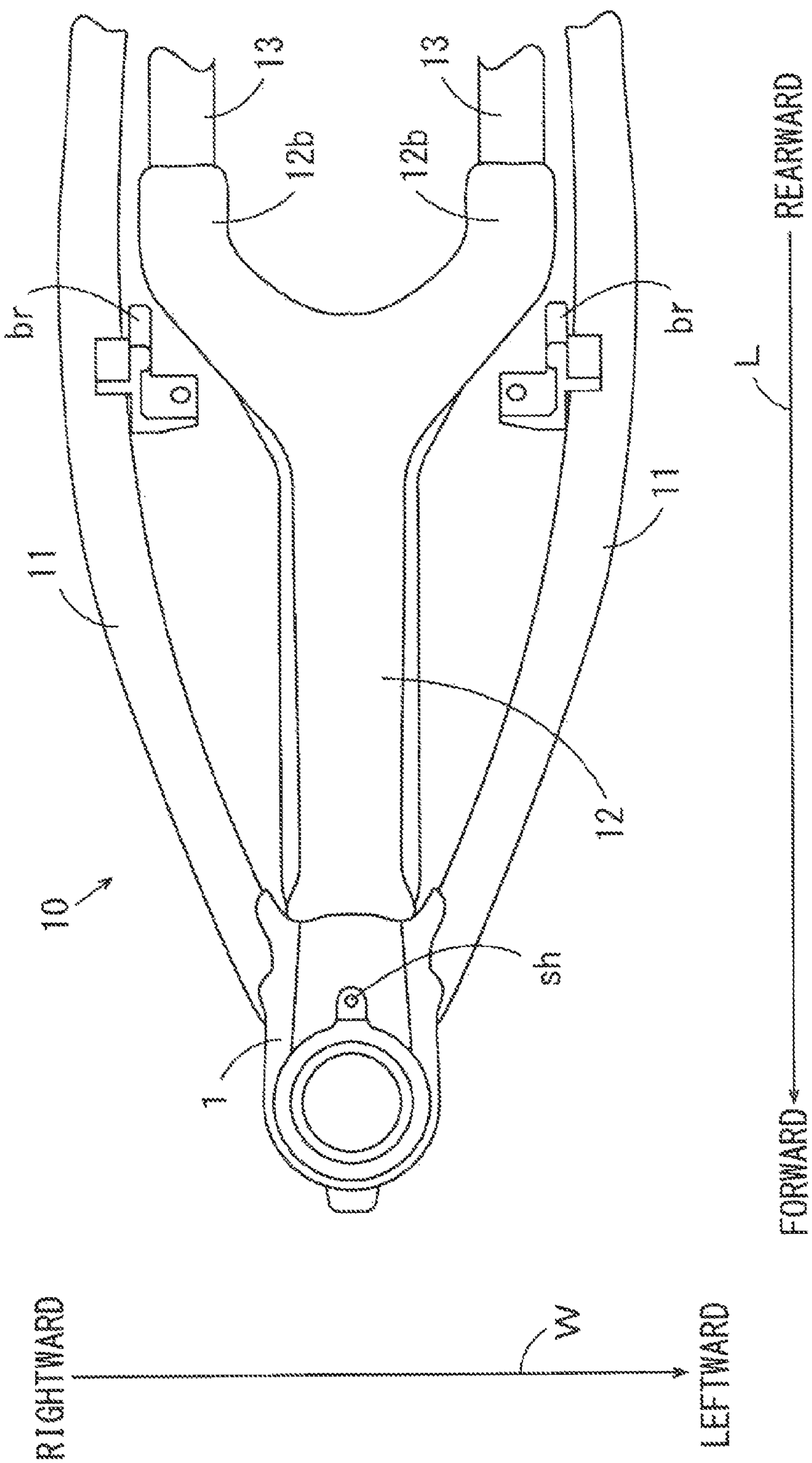
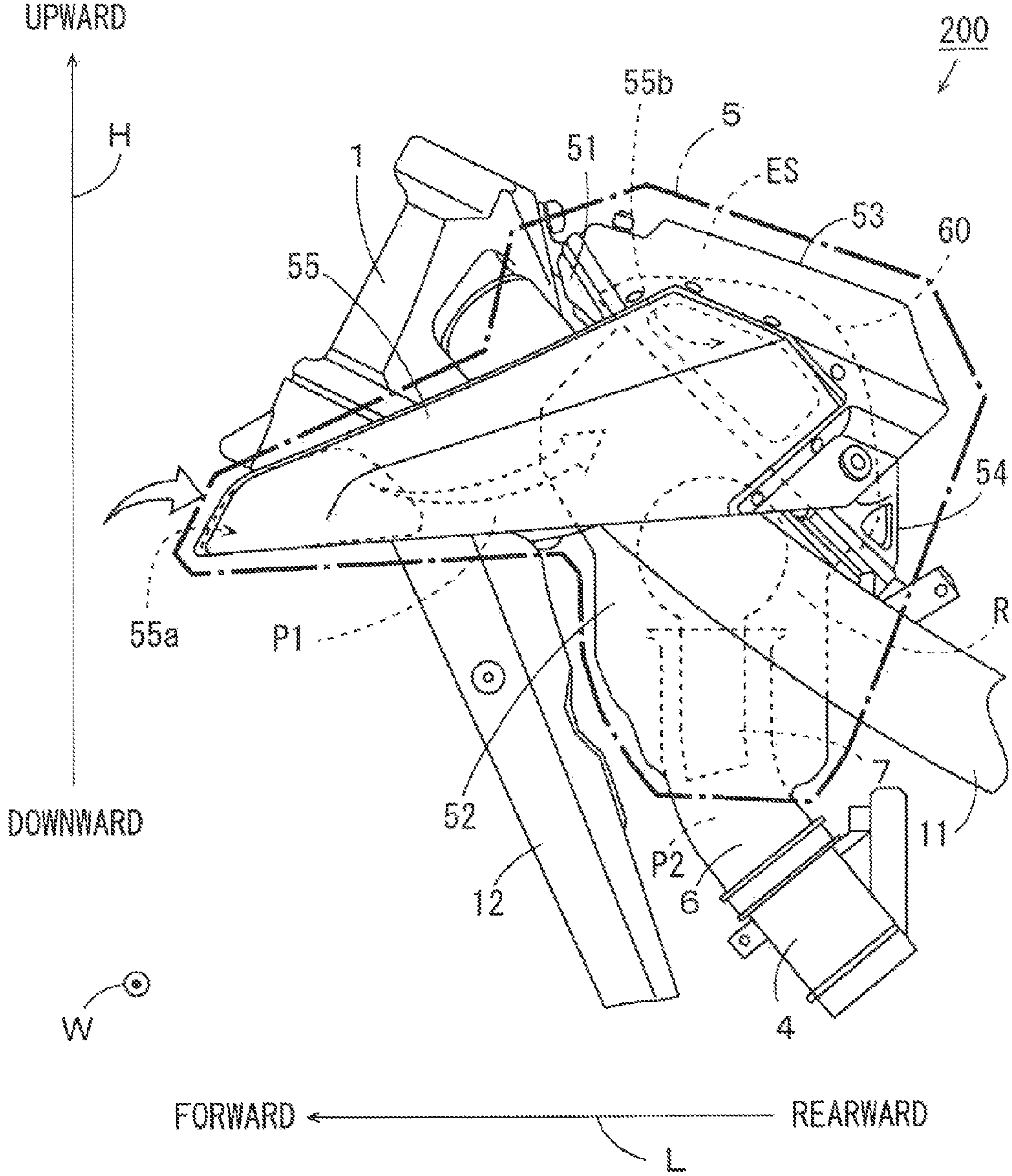
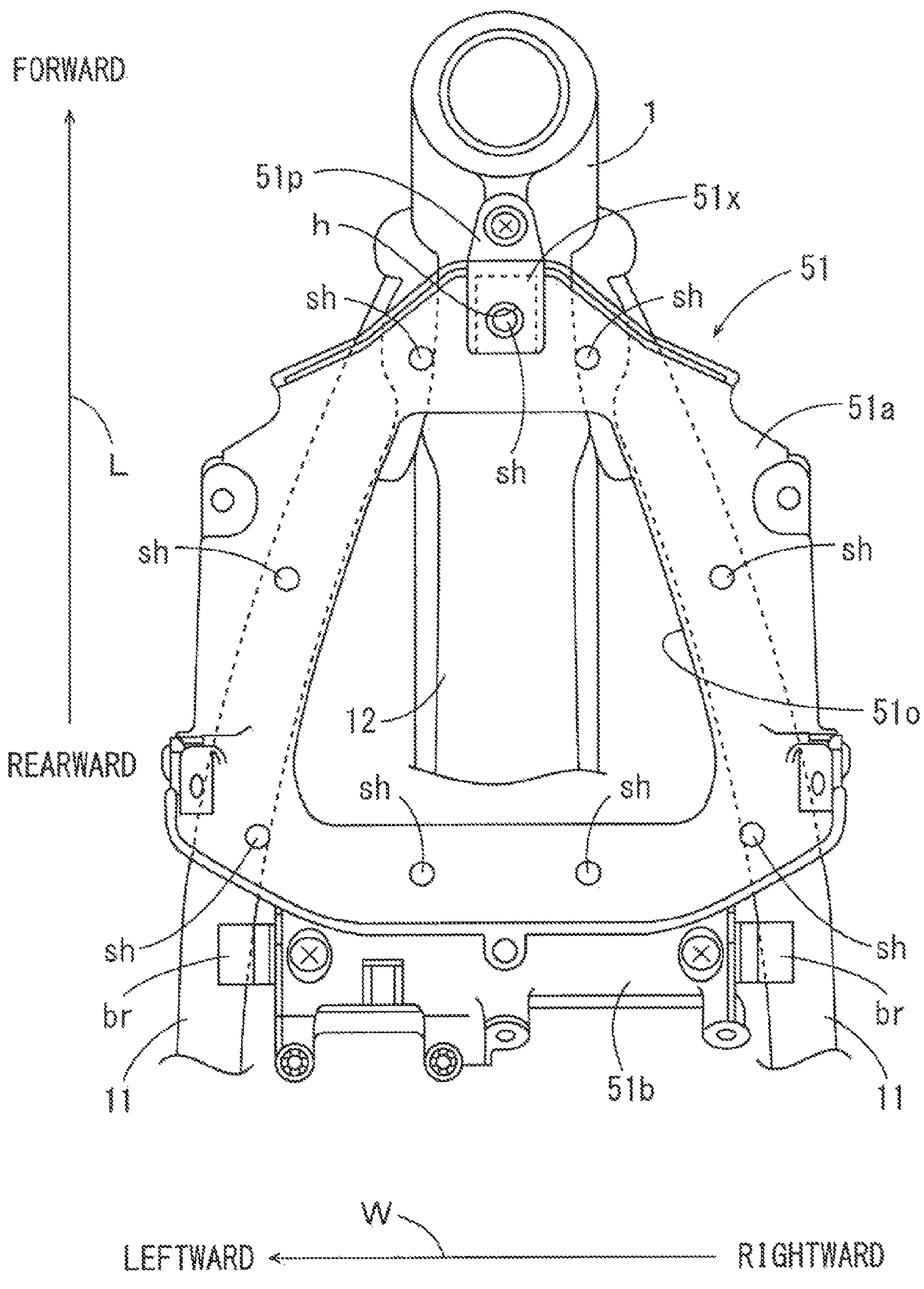

13
13
12b
12b
br
br
REARWARD
L
11
11
12
10
sh
1
FORWARD
RIGHTWARD
W
LEFTWARD

FIG. 2

F I G. 3


UPWARD
H
DOWNWARD
200
55b
5
51
ES
1
53
60
55
54
55a
P1
RS
52
7
11
P2
6
12
4
W
FORWARD
REARWARD
L

F I G. 4



FORWARD
REARWARD
L
1
51p
51x
h
51
sh
51a
12
51o
br
11
51b
W
LEFTWARD
RIGHTWARD

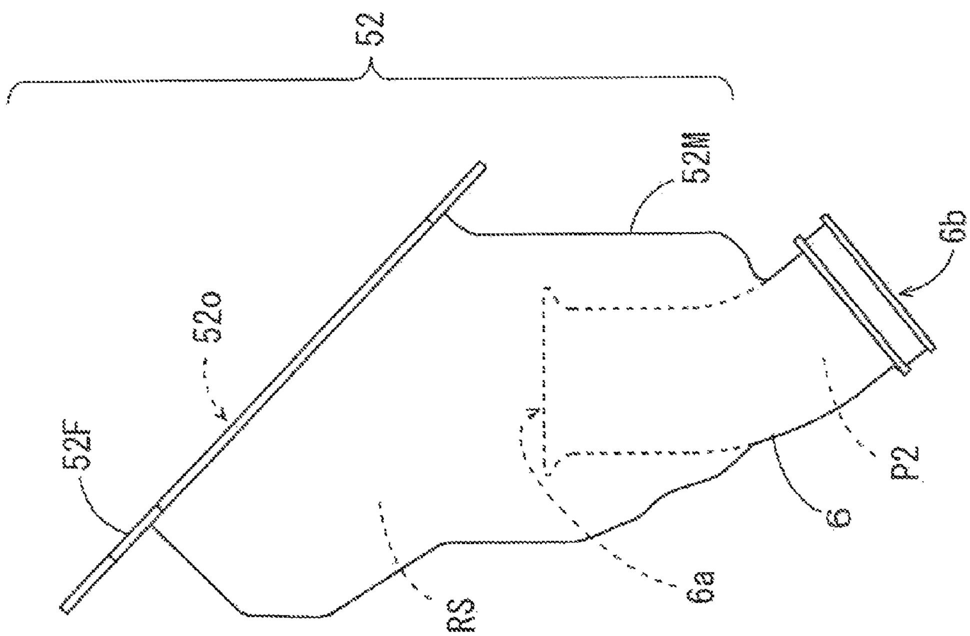


FIG. 5B

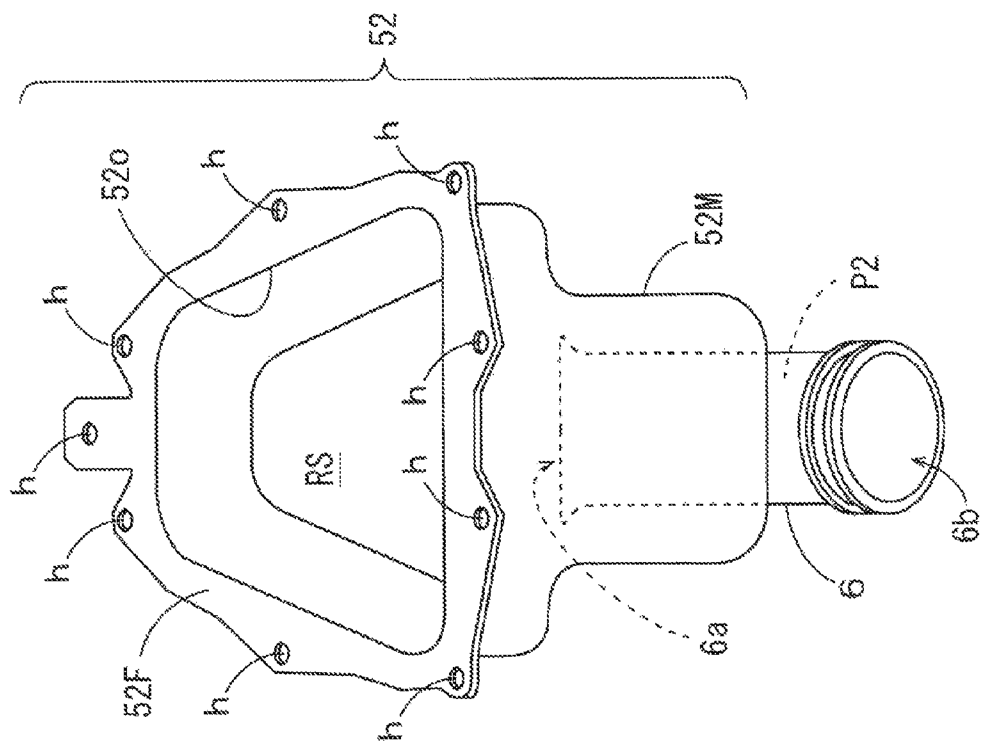
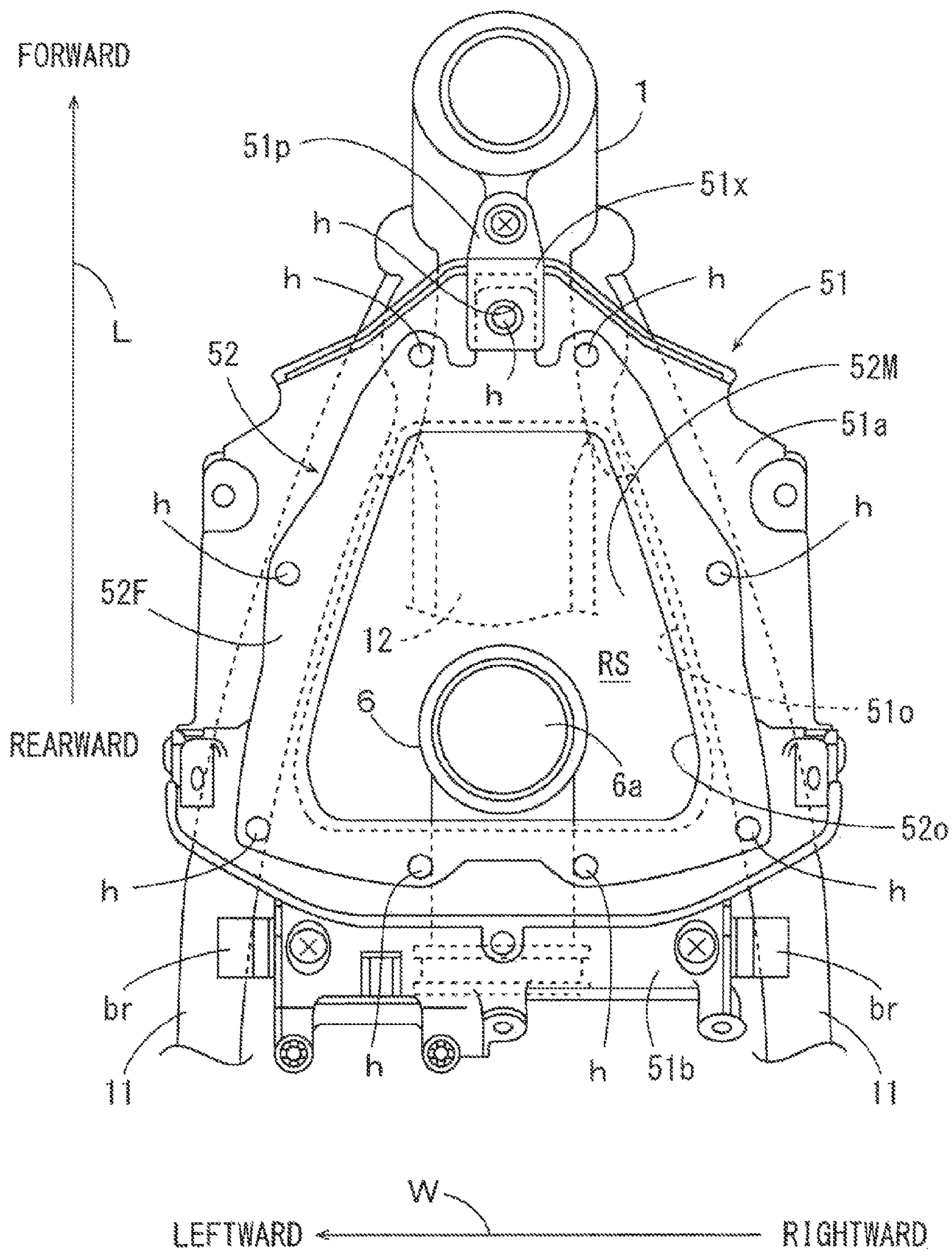
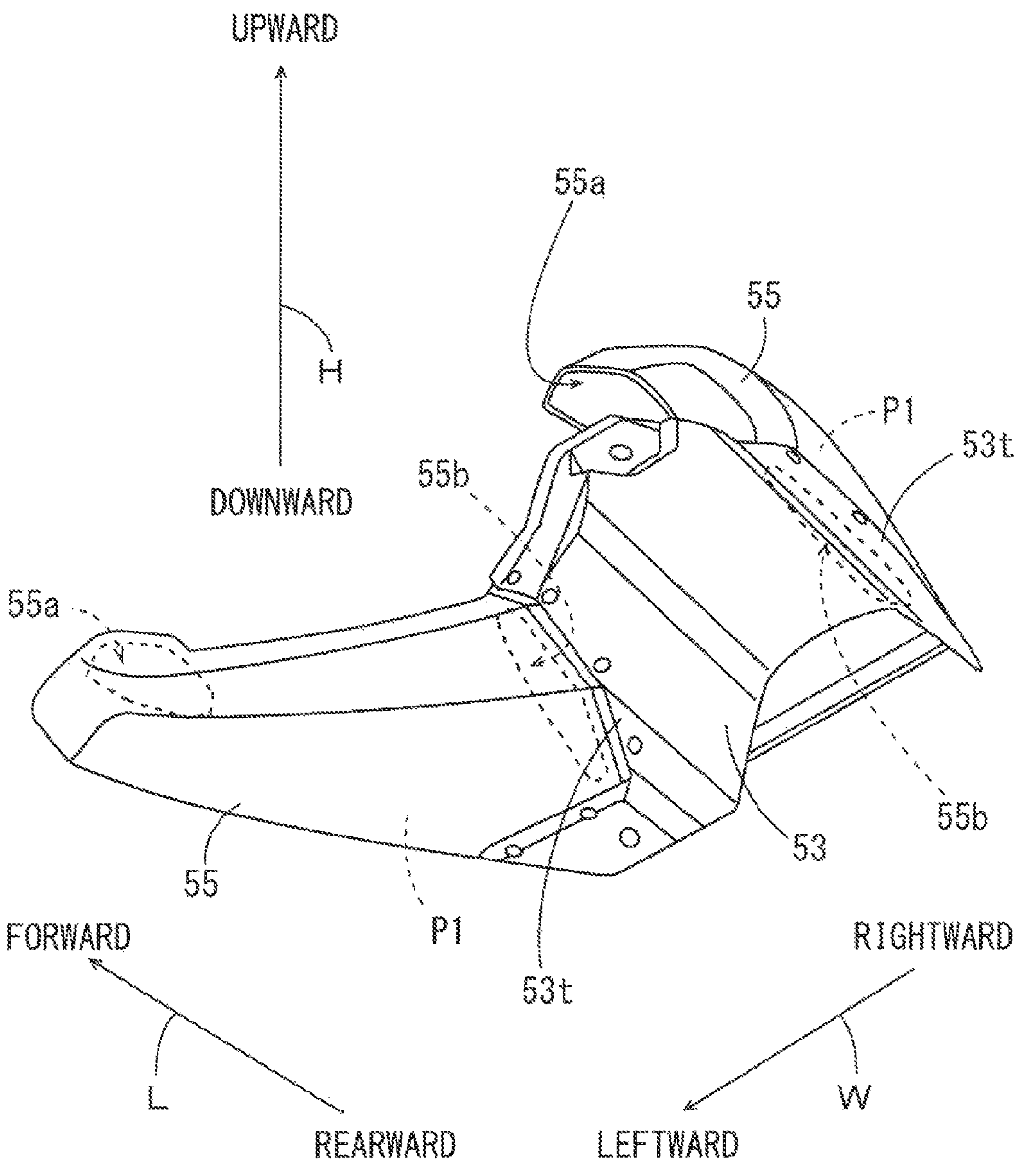


FIG. 5A

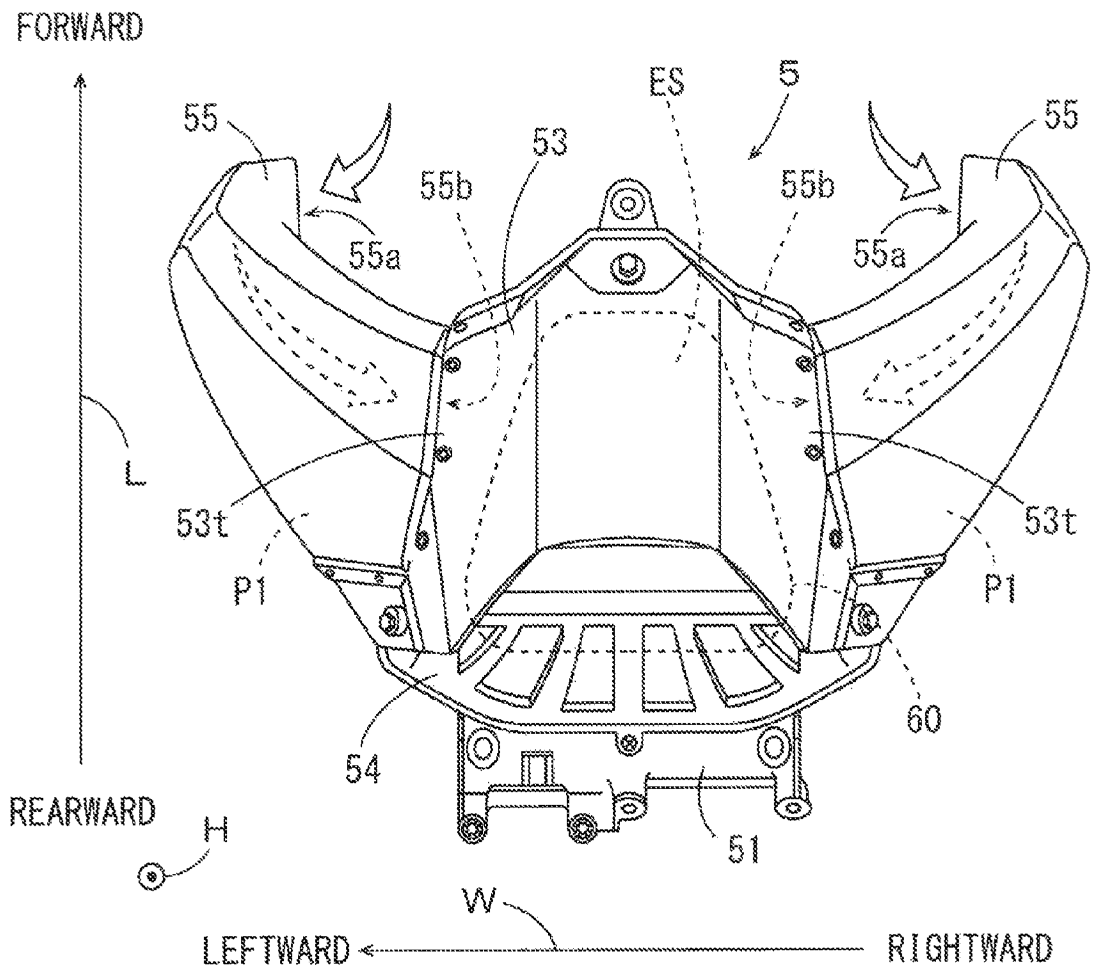
F I G. 6


FORWARD
L
REARWARD
1
51p
51x
h
51
52
52M
51a
52F
12
RS
6
6a
51o
52o
br
11
51b
W
LEFTWARD
RIGHTWARD

F I G. 7


UPWARD
H
DOWNWARD
55a
55
P1
53t
55b
55a
53
55b
55
P1
53t
FORWARD
RIGHTWARD
L
W
REARWARD
LEFTWARD

F I G. 8



FORWARD
55
ES
5
55
53
55b
55b
55a
55a
L
53t
53t
P1
P1
60
54
REARWARD
H
51
W
LEFTWARD
RIGHTWARD

F I G. 9

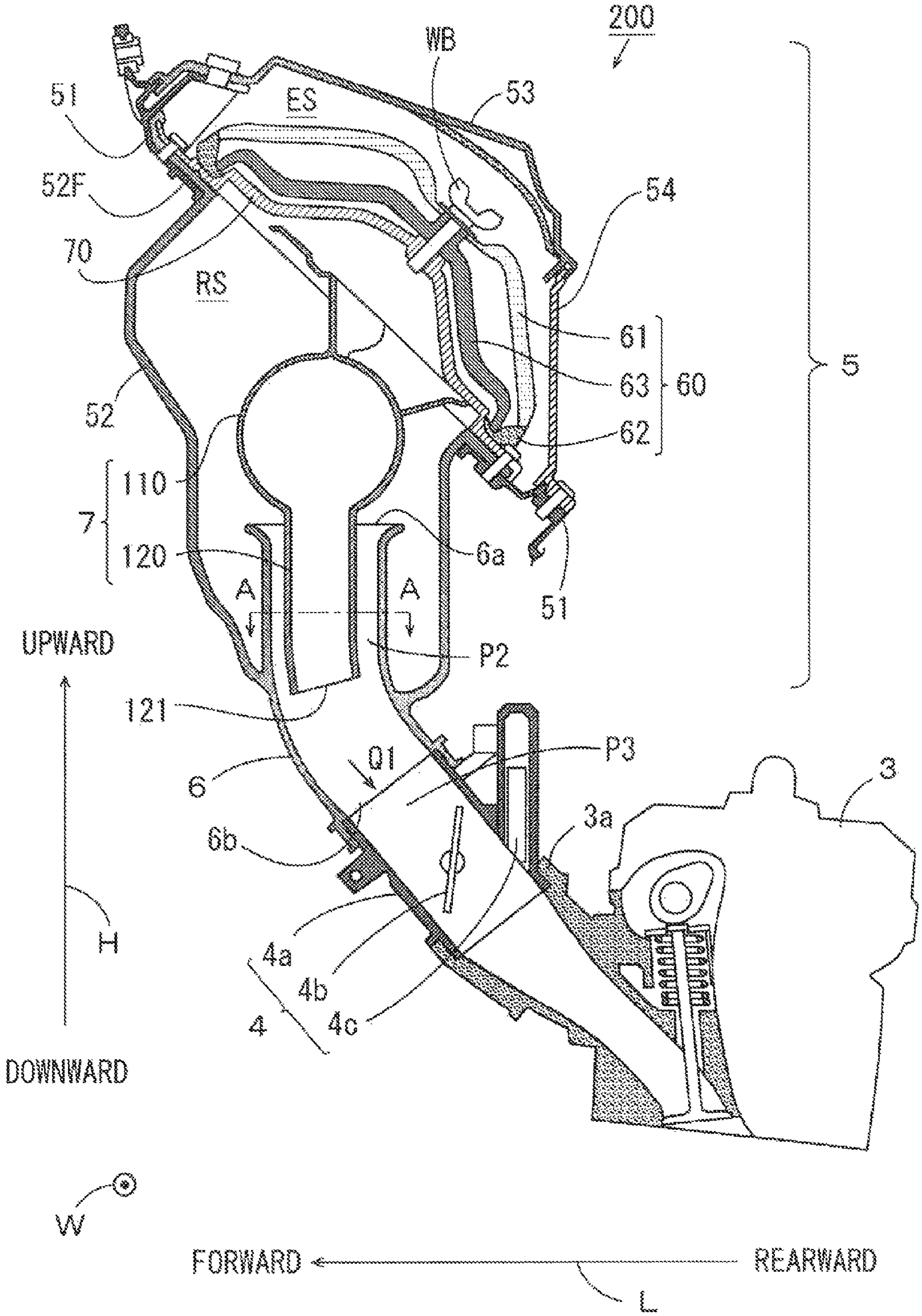

200
WB
53
ES
51
52F
54
70
RS
61
63
60
5
52
62
7
110
120
6a
51
A
A
UPWARD
P2
121
P3
Q1
3
6
3a
6b
H
4a
4b
4
4c
DOWNWARD
W
FORWARD
REARWARD
L

FIG. 10

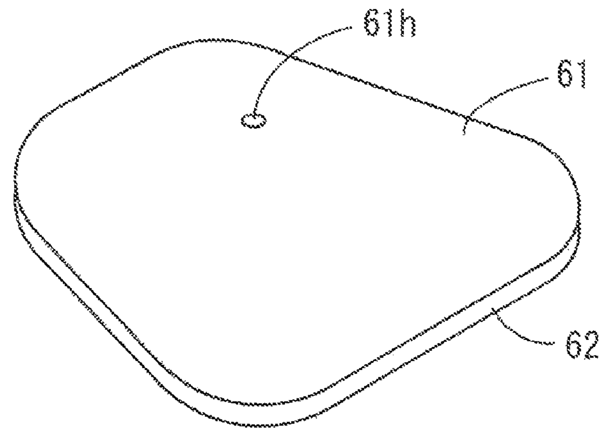


FIG. 11

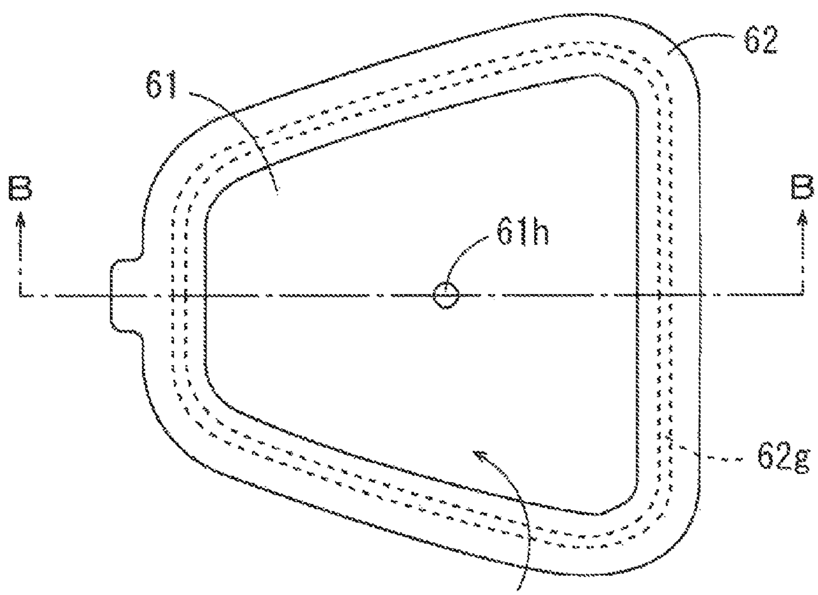


FIG. 12

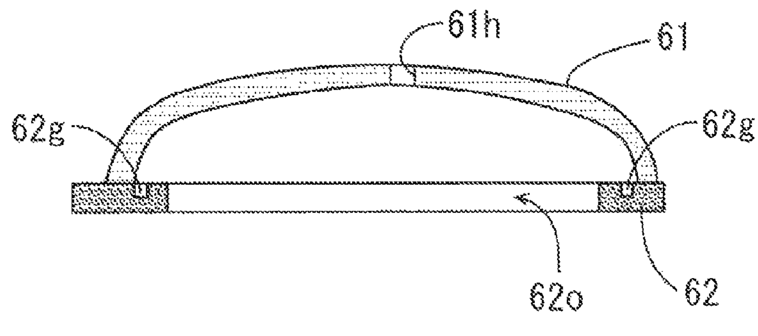


FIG. 13A

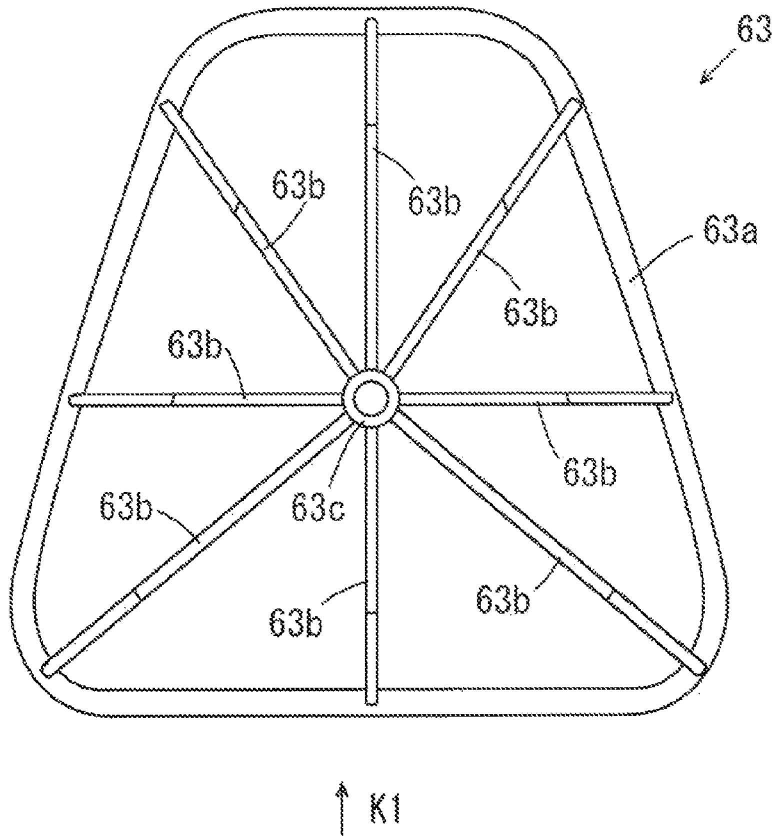


FIG. 13B

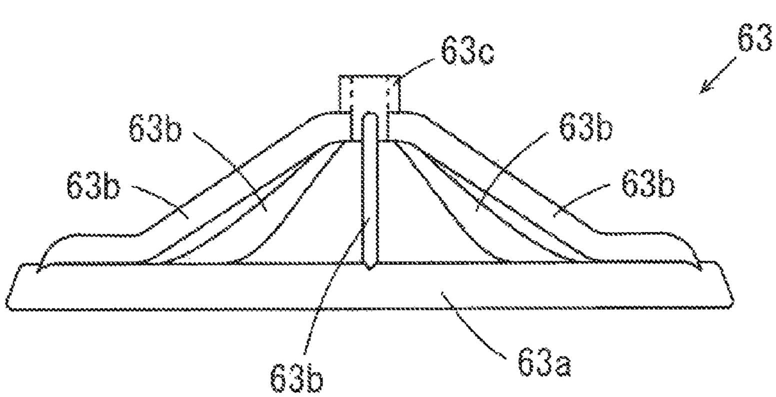


FIG. 14B

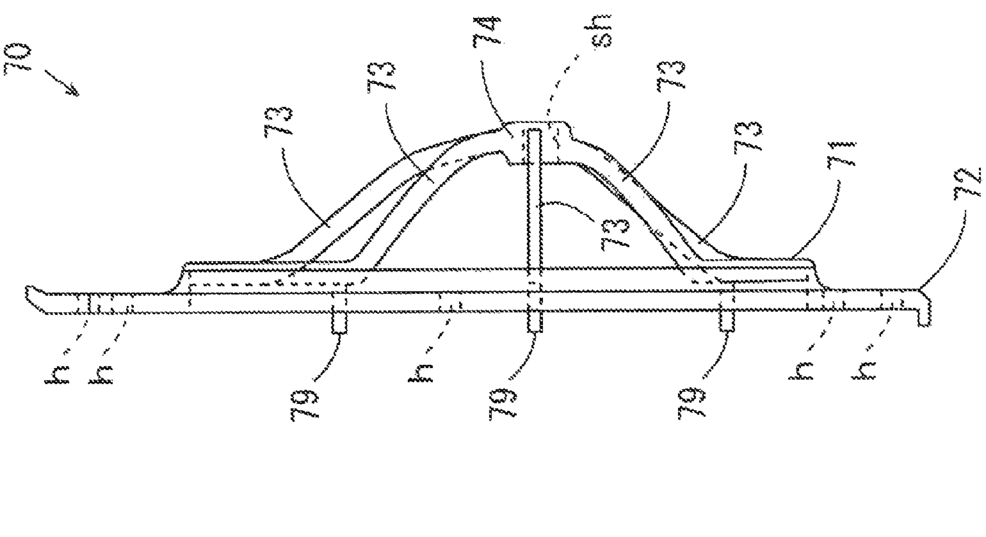
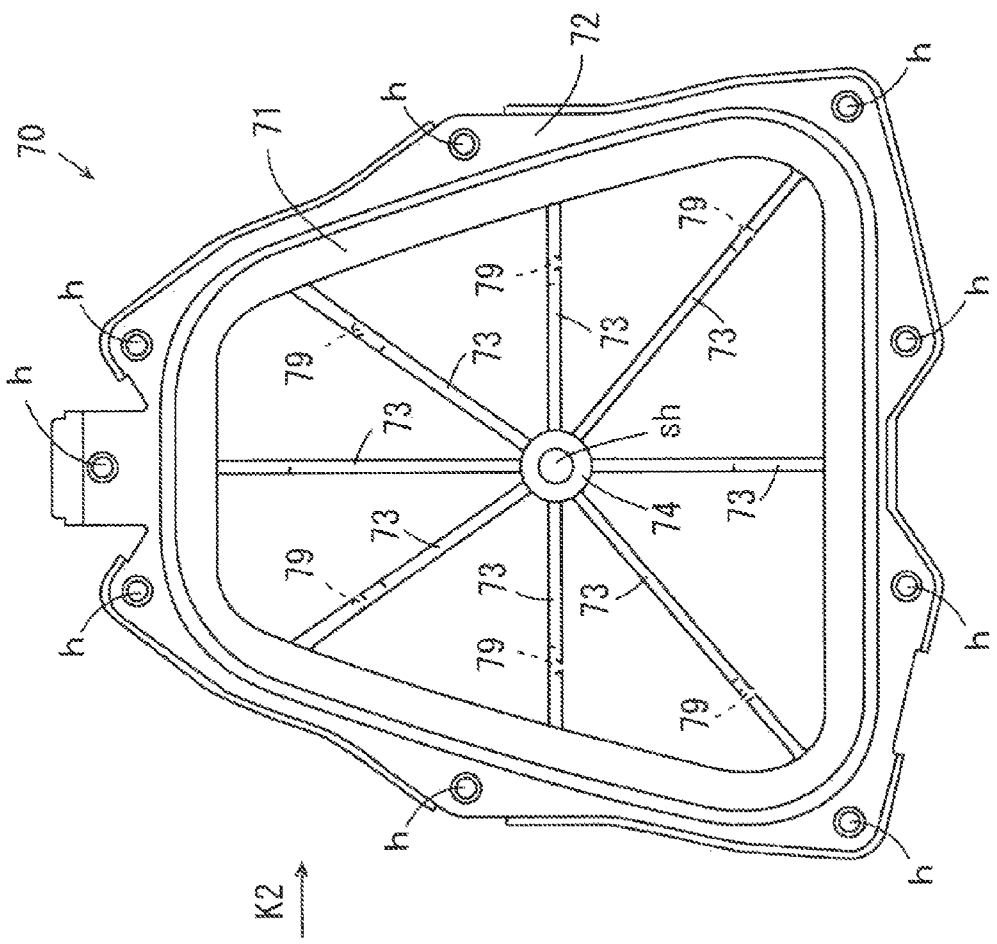


FIG. 14A



F I G. 15

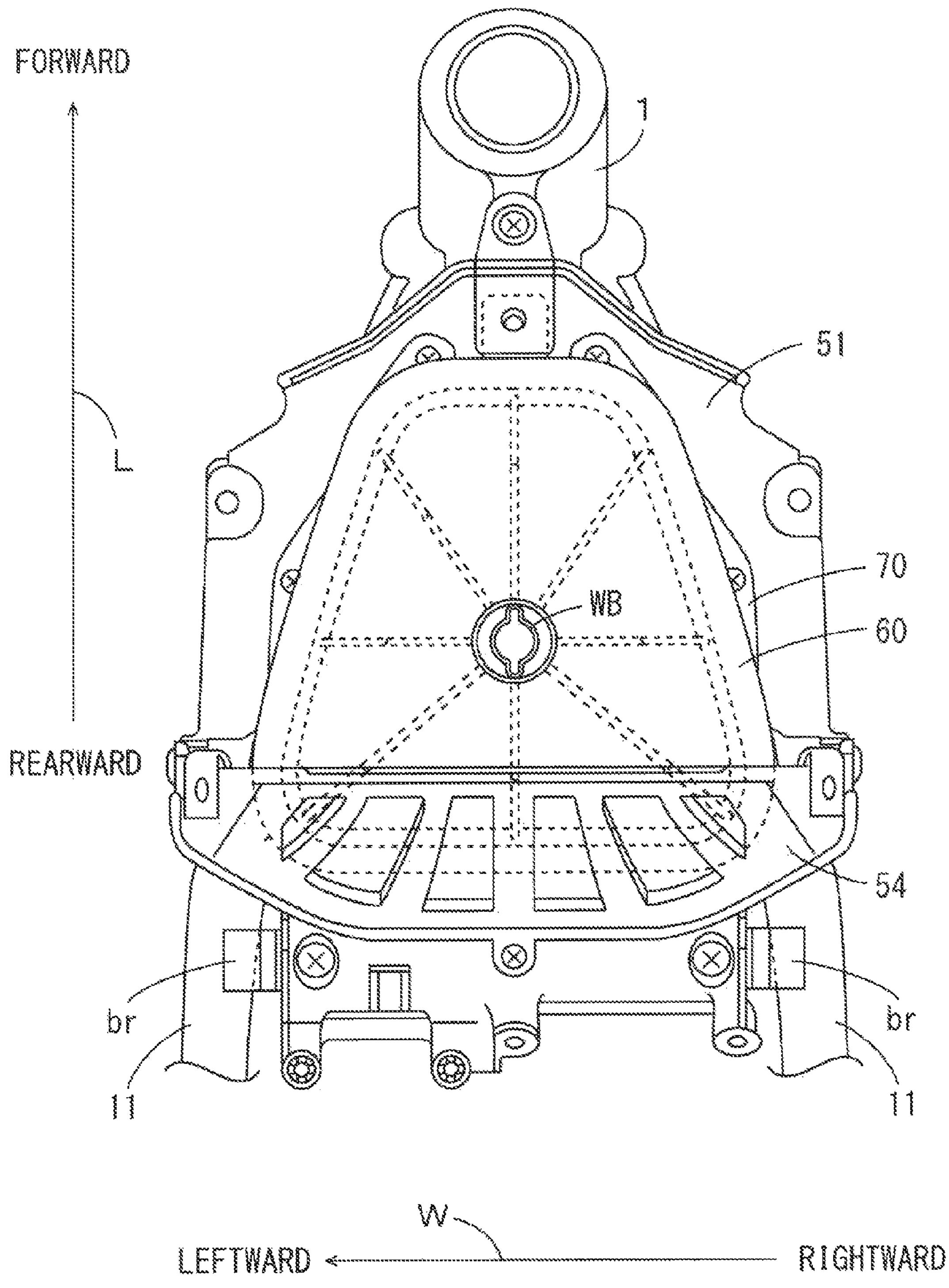

FORWARD
1
51
L
70
WB
60
REARWARD
54
br
br
11
11
W
LEFTWARD
RIGHTWARD

FIG. 16

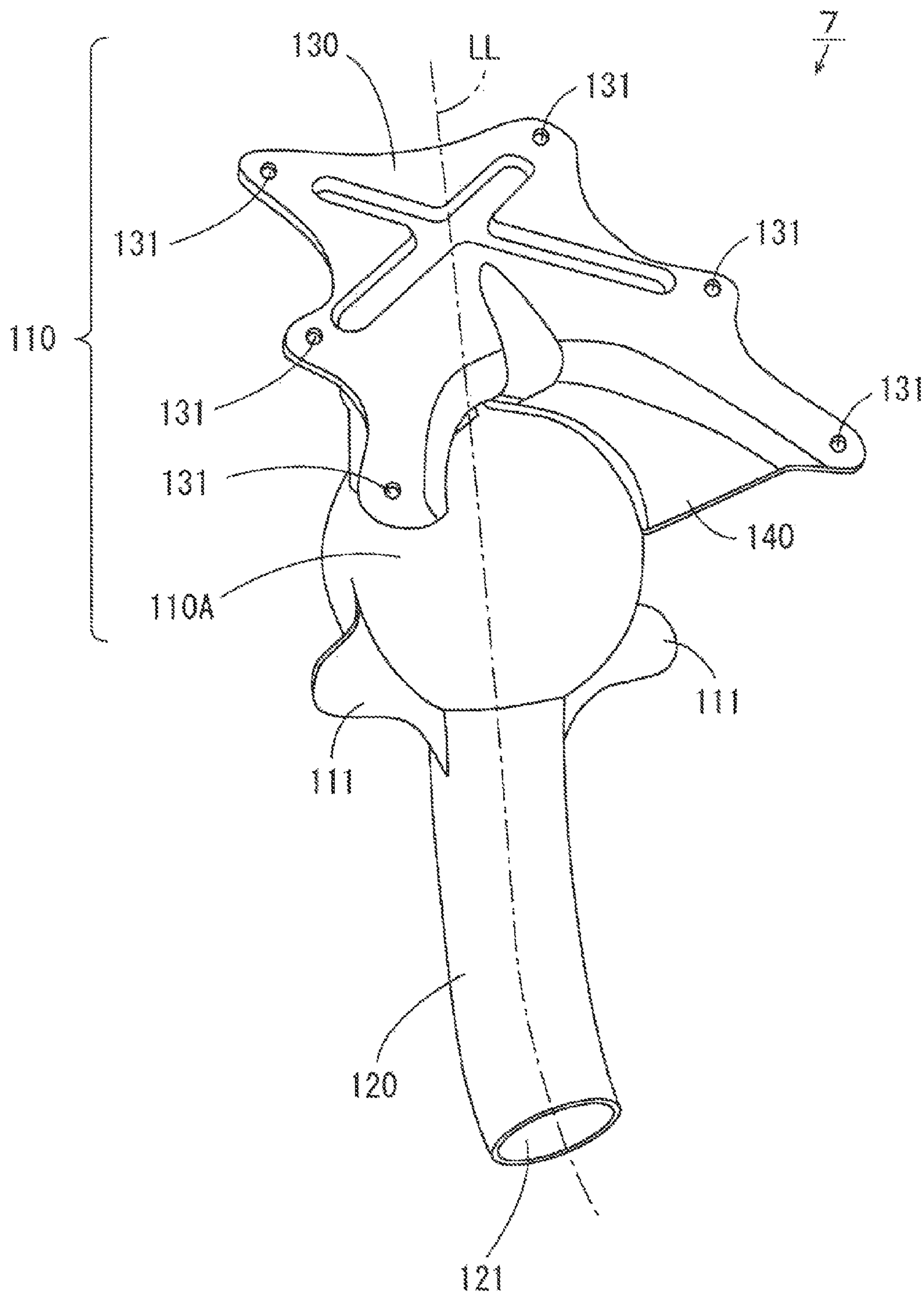


FIG. 17B

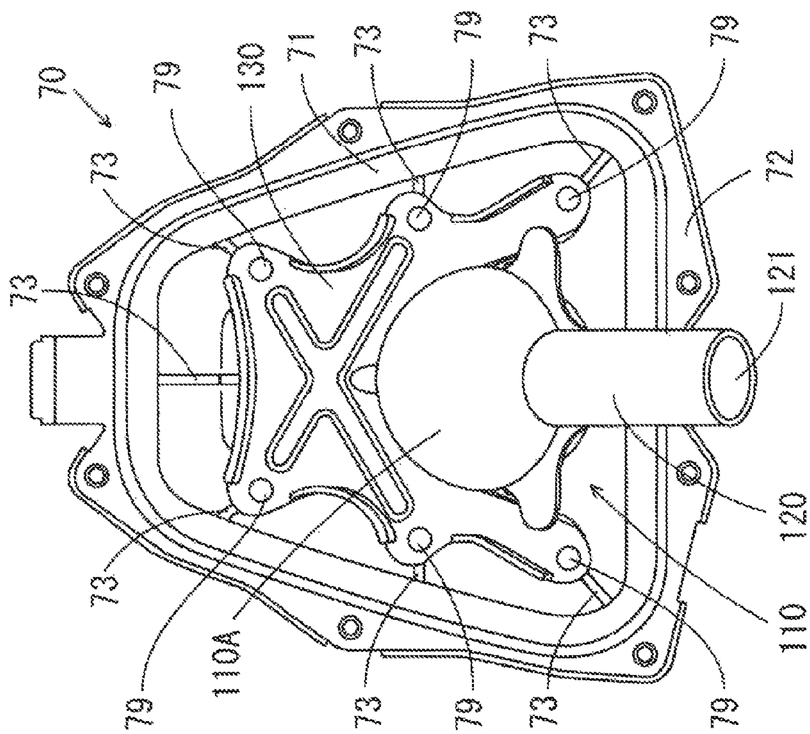


FIG. 17A

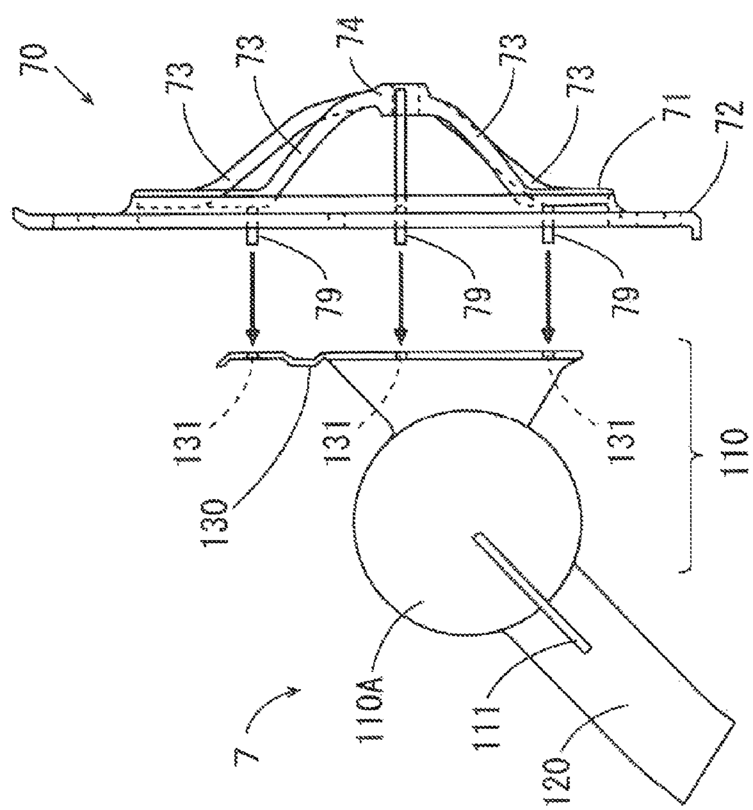


FIG. 18

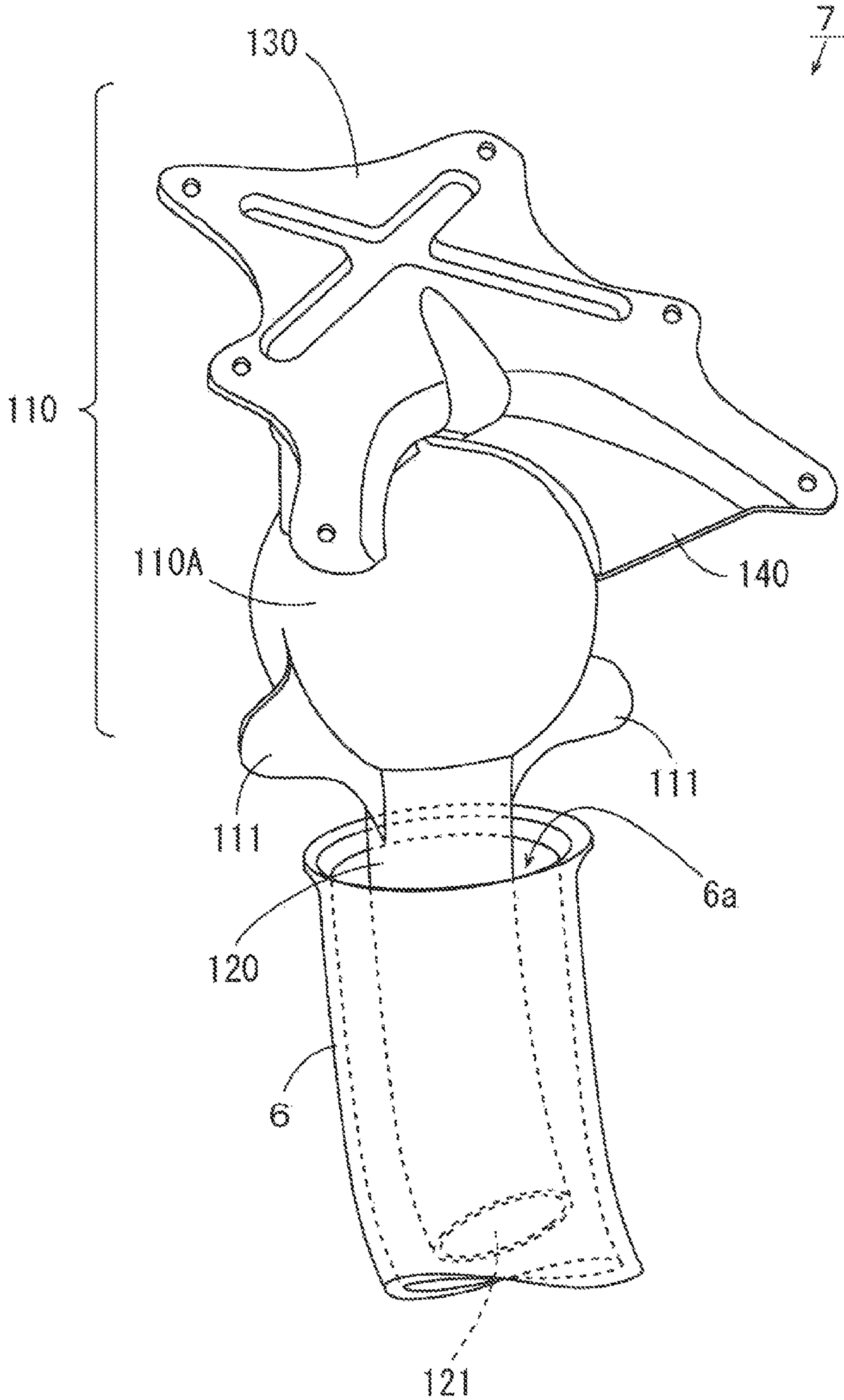


FIG. 19A

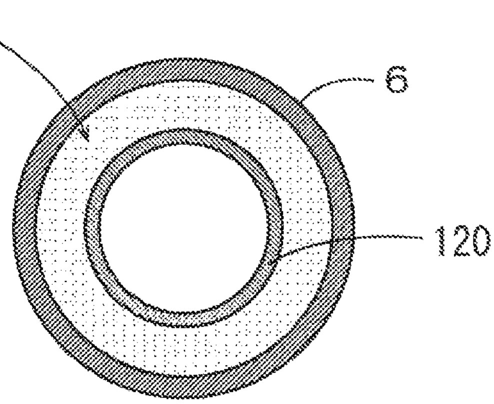


FIG. 19B

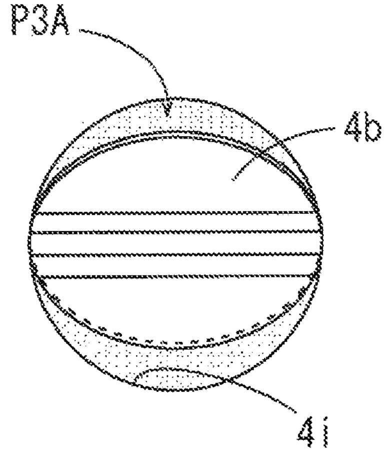


FIG. 20A

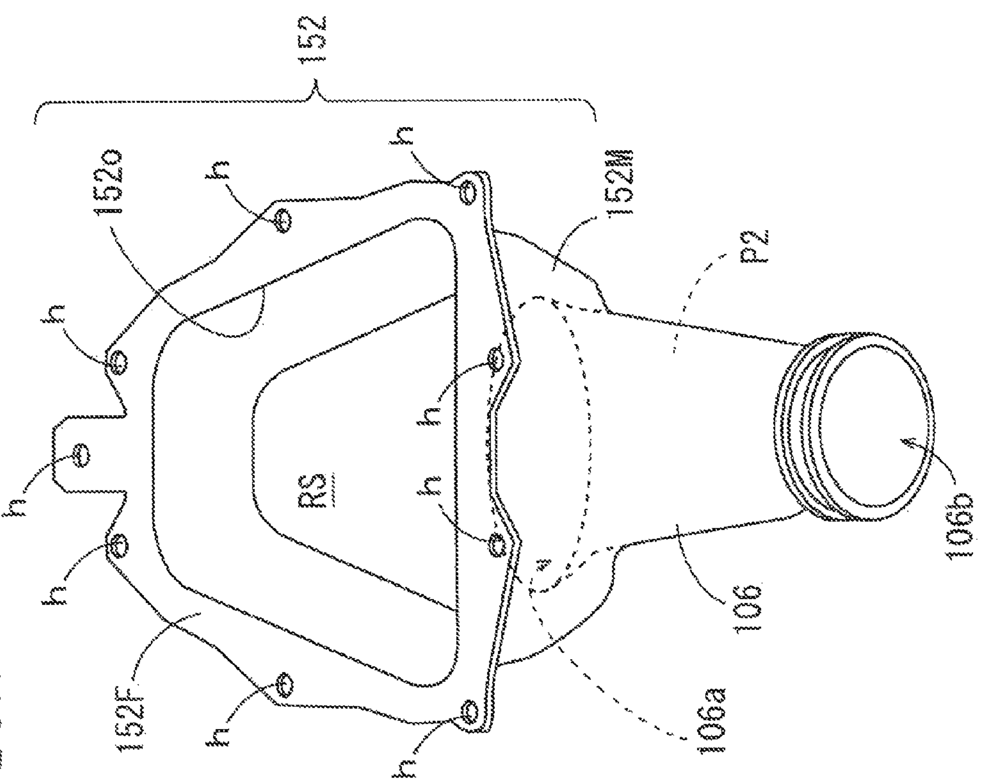


FIG. 20B

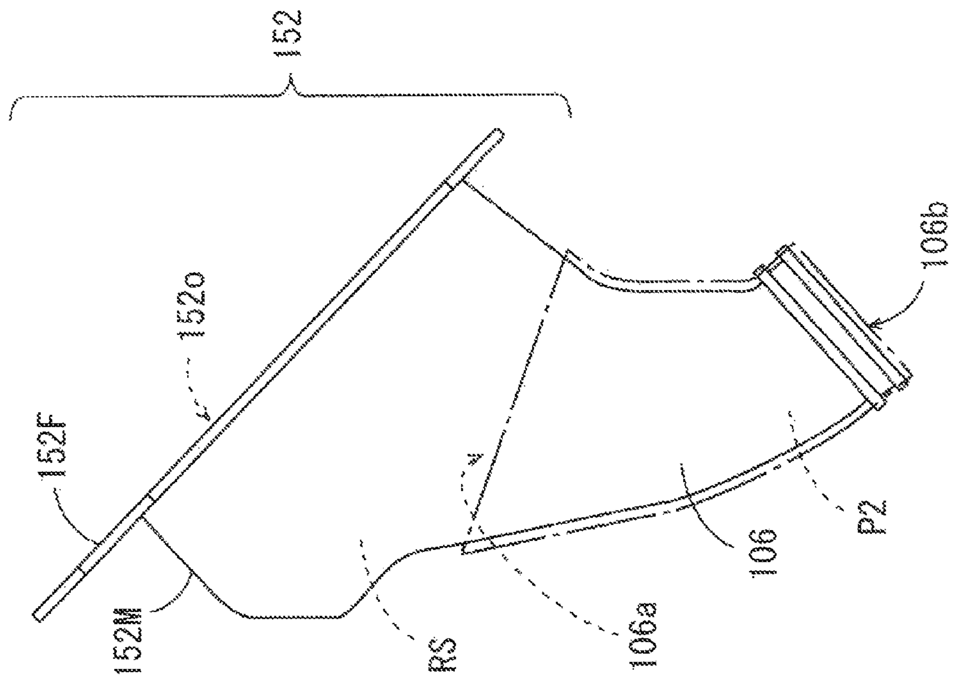


FIG. 21

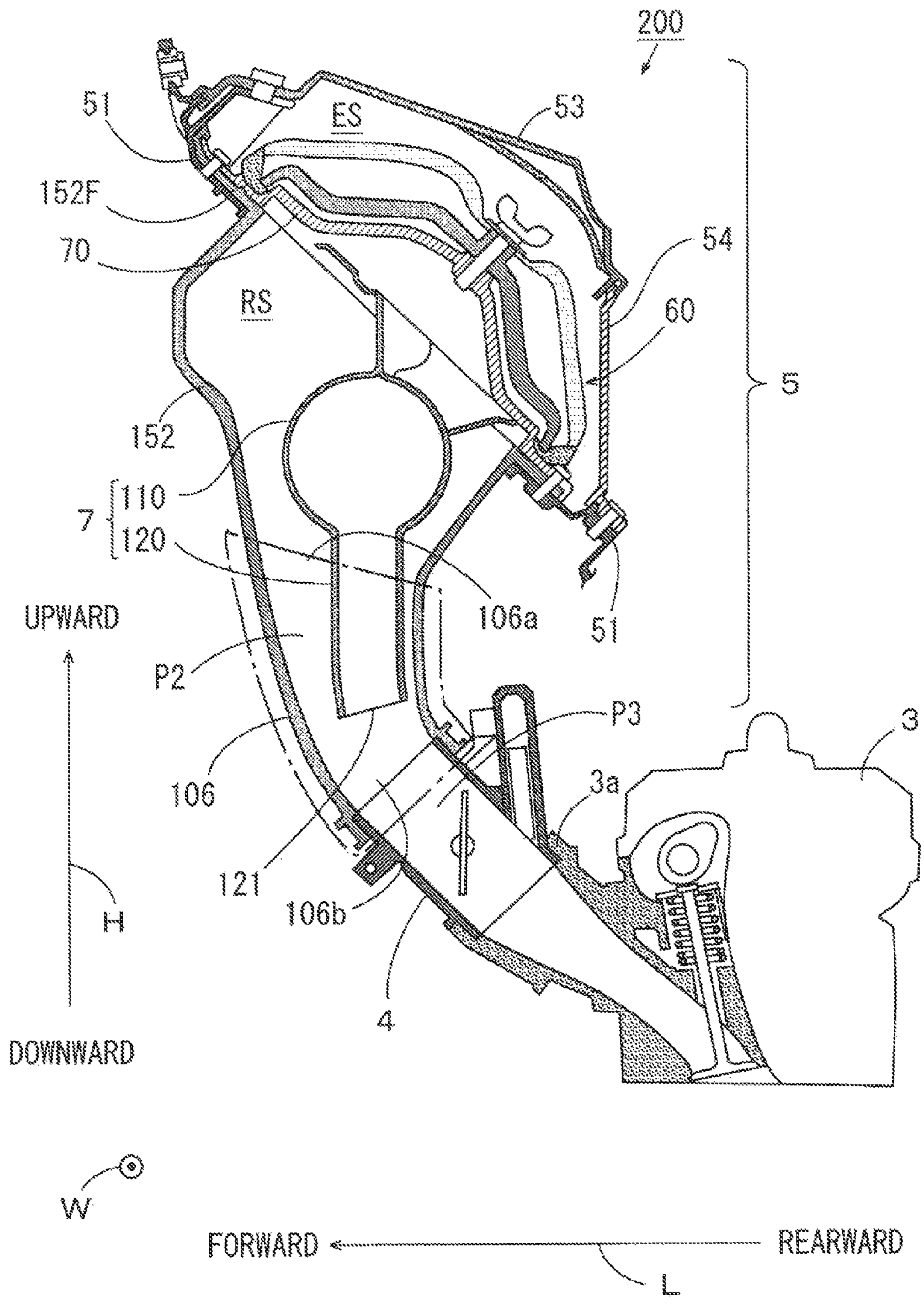

200
53
51
ES
152F
54
70
60
RS
5
152
7
110
120
106a
51
UPWARD
P2
P3
3
106
3a
121
106b
H
4
DOWNWARD
W
FORWARD
REARWARD
L

FIG. 22

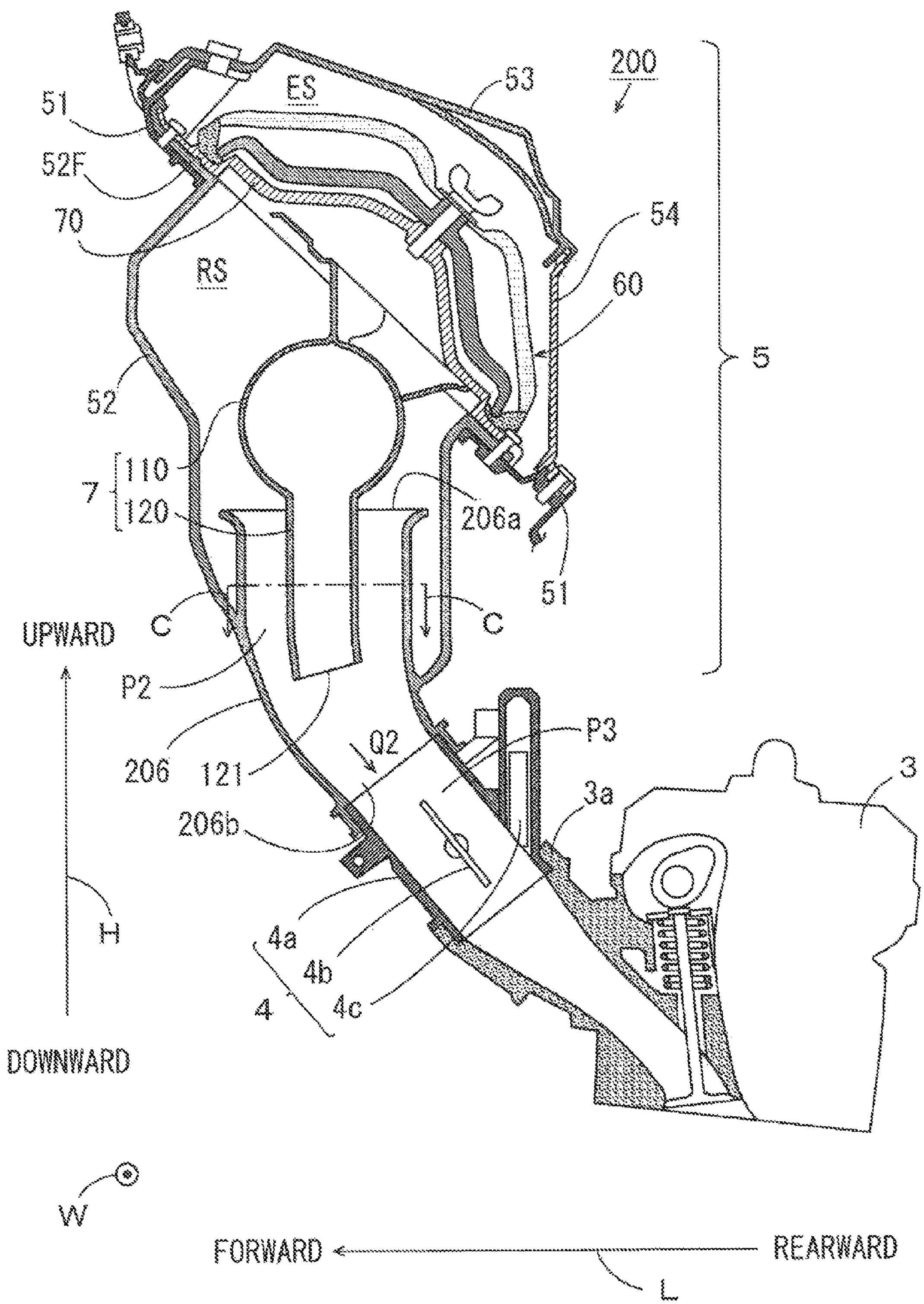

200
ES
53
51
52F
70
RS
54
60
5
52
7
110
120
206a
51
C
C
UPWARD
P2
206
121
Q2
P3
3
3a
206b
H
4a
4b
4c
4
DOWNWARD
W
FORWARD
REARWARD
L

FIG. 23A

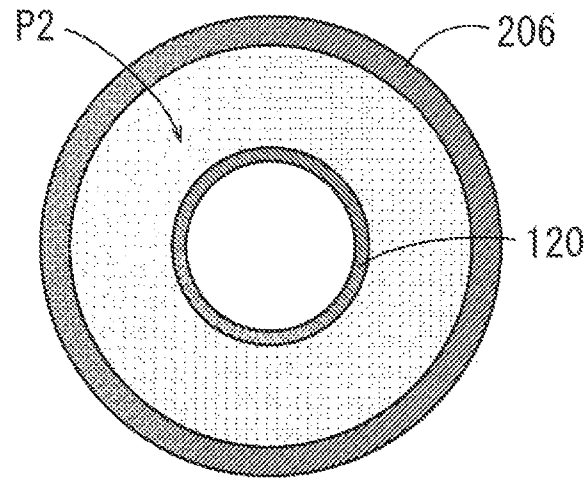


FIG. 23B

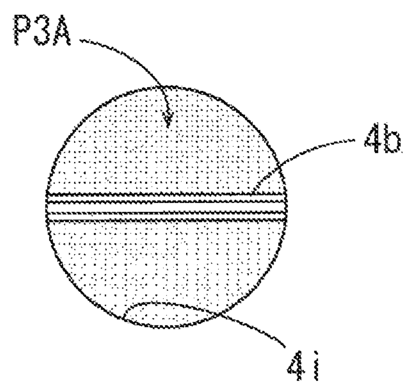
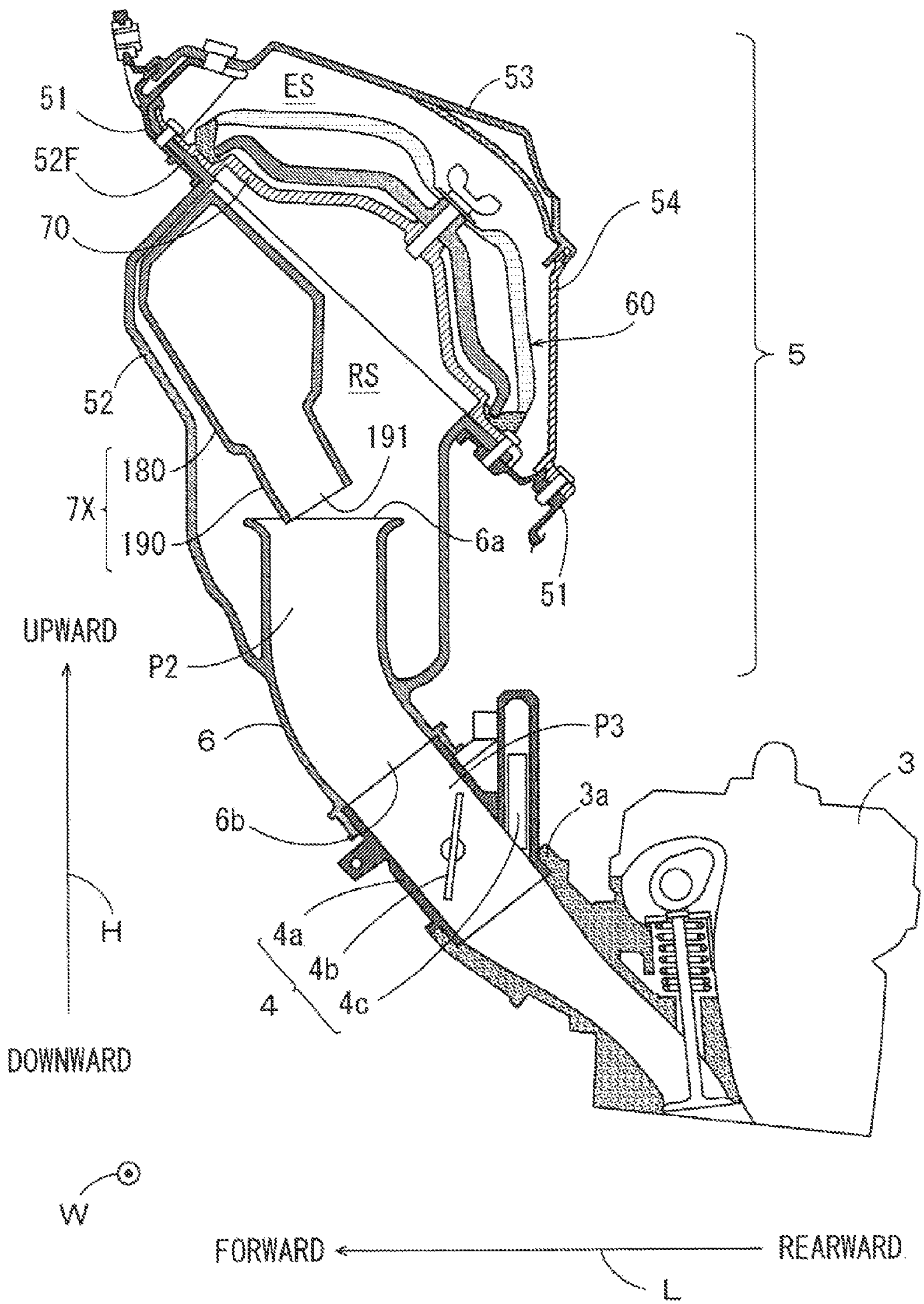
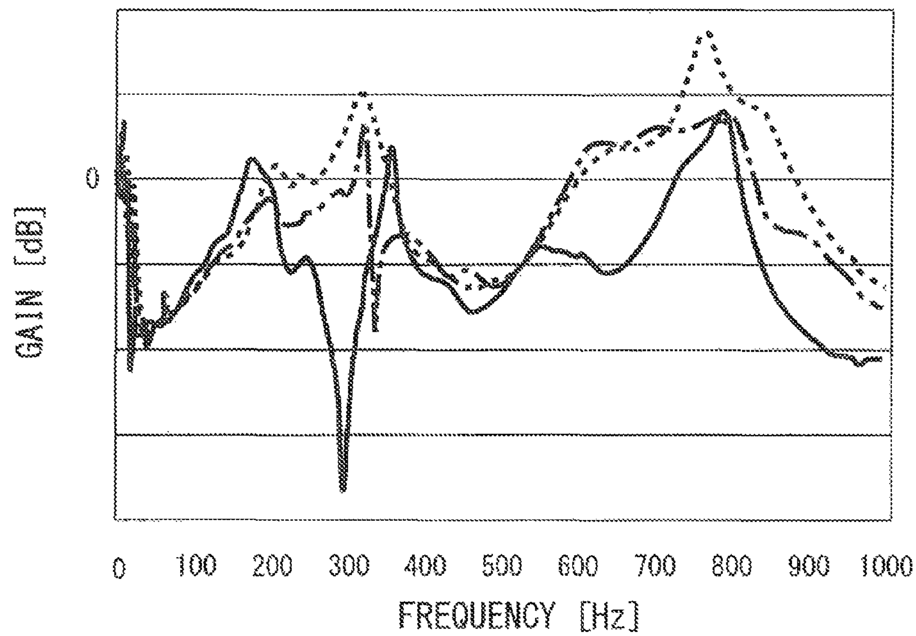


FIG. 24



ES
53
51
52F
54
70
60
5
RS
52
191
180
7X
190
6a
51
UPWARD
P2
6
P3
3
3a
6b
H
4a
4a
4b
4
4c
DOWNWARD
W
FORWARD
REARWARD
L

F I G. 25

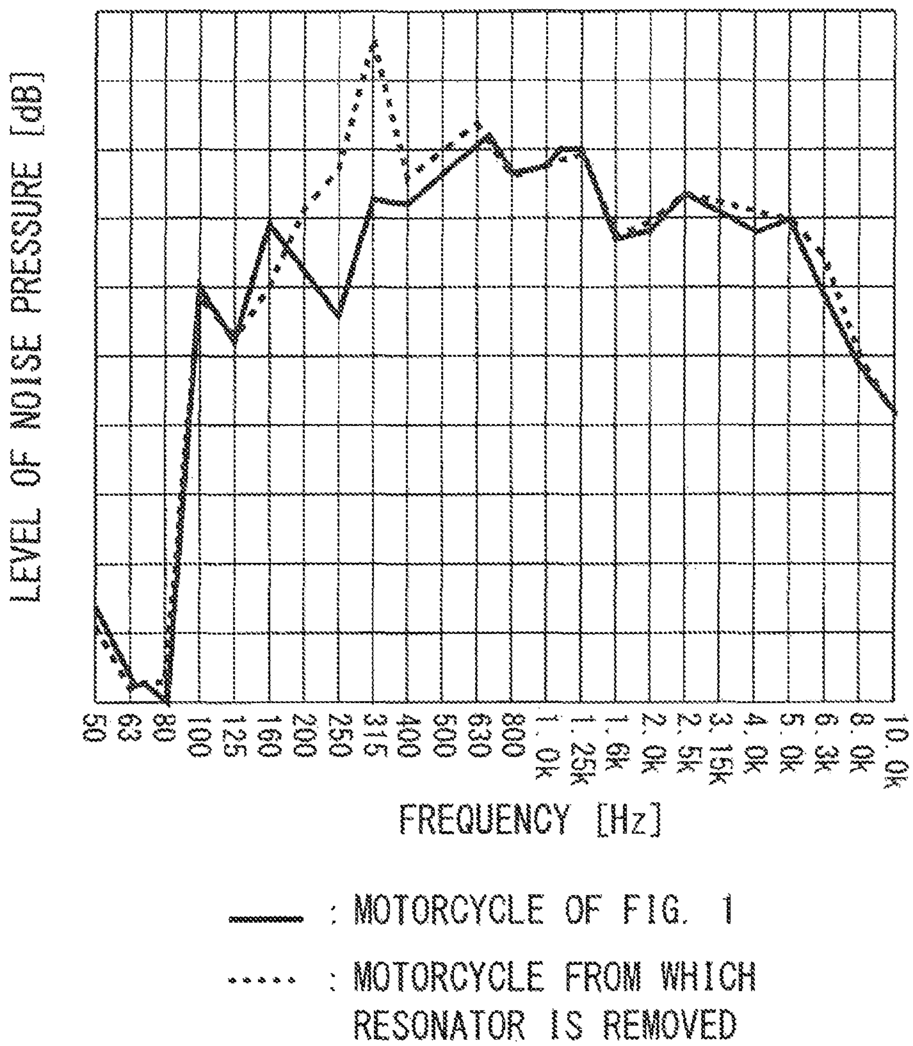


—— : INTAKE NOISE REDUCTION DEVICE OF FIG. 9

····· : CONFIGURATION IN WHICH RESONATOR IS REMOVED FROM INTAKE NOISE REDUCTION DEVICE OF FIG. 9

-·-— : INTAKE NOISE REDUCTION DEVICE OF FIG. 24

F I G. 26


LEVEL OF NOISE PRESSURE [dB]
50
63
80
100
125
160
200
250
315
400
500
630
800
1.0k
1.25k
1.6k
2.0k
2.5k
3.15k
4.0k
5.0k
6.3k
8.0k
10.0k
FREQUENCY [Hz]
: MOTORCYCLE OF FIG. 1
: MOTORCYCLE FROM WHICH RESONATOR IS REMOVED

INTAKE NOISE REDUCTION DEVICE AND STRADDLE-TYPE VEHICLE INCLUDING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based on, and claims priority to, Japanese Patent Application No. 2014-114615, filed on Jun. 3, 2014. The contents of the identified application is entirely incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an intake noise reduction device and a straddle-type vehicle including the intake noise reduction device.

2. Description of Related Art

A resonator is used to reduce noise generated from a motorcycle. For example, in a motorcycle described in JP 4-306183 A, an air cleaner casing is arranged below a seat, and a resonator is provided between the seat and the air cleaner casing. An inner space of the resonator and an inner space of an air introduction duct of the air cleaner casing communicate with each other via a communication passage (an opening). Thus, aerial vibration of intake noise of an engine transmitted to inside of the air introduction duct resonates with aerial vibration generated in the resonator, and is attenuated.

BRIEF SUMMARY OF THE INVENTION

It is known that the closer an opening of the resonator is to an intake valve positioned downstream of an intake passage, the more sufficiently improved a reduction in intake noise by the resonator is. A method of attachment of the resonator to the outside of an intake funnel that connects the air cleaner casing to an intake port of the engine is considered in order to bring the opening of the resonator closer to the intake valve. However, in this case, it may be difficult to ensure a necessary capacity of the resonator in order to acquire noise reduction effects depending on the layout of surroundings of the intake funnel including the resonator. Further, design may be limited when the resonator can be seen from outside.

An object of the present invention is to provide an intake noise reduction device capable of improving a reduction in intake noise of an engine without limitation of a layout and design of surroundings of an intake system and a straddle-type vehicle including the intake noise reduction device.

(1) An intake noise reduction device according to one aspect of the present invention that leads air to an engine includes an air cleaner, an intake funnel having an upstream opening positioned in the air cleaner, a throttle body provided between a downstream opening of the intake funnel and an intake port of the engine, and a resonator having a chamber portion and a pipe portion, wherein the resonator is arranged in the air cleaner such that an opening end of the pipe portion is inserted into the intake funnel, and a cross sectional area of a passage formed between an inner peripheral surface of the intake funnel and an outer peripheral surface of the pipe portion is set to not less than an opening area of an intake passage of the throttle body opened to a maximum throttle opening.

In the intake noise reduction device, the opening end of the pipe portion of the resonator is inserted into the intake funnel, so that the opening end of the pipe portion of the resonator is close to an intake valve positioned downstream of the intake

passage. Thus, noise reduction is improved. Further, the resonator is arranged in the air cleaner, so that limitation of the layout and design of the surroundings of the intake funnel due to the presence of the resonator is prevented.

In this case, the cross sectional area of the passage formed between the inner peripheral surface of the intake funnel and the outer peripheral surface of the pipe portion is set to not less than the opening area of the intake passage of the throttle body opened to the maximum throttle opening, whereby the intake amount in the intake passage of the throttle body is not limited by the pipe portion of the resonator inserted into the intake funnel. Therefore, a reduction in intake performance of the engine is prevented.

As a result, a reduction in intake noise of the engine can be improved without limitation of the layout and design of the surroundings of the intake system.

Further, it is unnecessary to provide a member for preventing deformation and damage of the resonator due to contact with another object in the surroundings of the intake system because of the above-mentioned configuration. Therefore, an increase in number of components is inhibited.

(2) The air cleaner may include a filter element, a casing that stores the filter element, and a support member that supports the filter element on the casing at a position further upstream than the intake funnel, and the chamber portion of the resonator may be provided at a position further downstream than the filter element.

In this case, the chamber portion is provided at a position further downstream than the filter element, so that a space located at a position further downstream than the filter element in the air cleaner can be effectively utilized. Therefore, it is possible to improve the noise reduction without increasing the size of the air cleaner.

(3) The chamber portion of the resonator may have an attachment portion attached to the support member.

The attachment portion of the chamber portion is attached to the support member, so that the passage between the pipe portion and the intake funnel can be ensured with the resonator being supported at the casing.

(4) The attachment portion may include a plate-shape member provided to close part of a space located at a position further downstream than the filter element.

In this case, the plate-shape member functions as a noise insulator. Thus, the intake noise leaking to space located at a position further upstream than the filter element is reduced by the plate-shape member. Therefore, a reduction in intake noise can be more sufficiently improved. Further, the plate-shape member functions as the attachment portion and the noise insulator, so that an increase in number of components is inhibited.

(5) The resonator may have a projection projecting outward of the upstream opening of the intake funnel, and a lower edge of the projection may be formed to extend outward from the pipe portion.

In this case, even when the support of the resonator in the air cleaner comes off, the lower edge of the projection is caught by the upstream opening of the intake funnel. Thus, the chamber portion of the resonator is prevented from closing the upstream opening of the intake funnel.

(6) A straddle-type vehicle according to another aspect of the present invention includes the engine, a drive wheel rotated by motive power generated by the engine, and the above-mentioned intake noise reduction device that leads air to the engine.

The straddle-type vehicle includes the above-mentioned intake noise reduction device. Thus, a reduction in intake noise of the engine can be improved without limitation of the layout and design of the surroundings of the intake system.

Further, an increase in number of components in the surroundings of the intake system is inhibited.

(7) The straddle-type vehicle further includes a head pipe, a main frame that extends rearward of the vehicle from the head pipe, and a down frame that obliquely extends rearward and downward from the head pipe at a position below the main frame, wherein the air cleaner is supported at a front portion of the main frame, the engine is held by the main frame at a position below the air cleaner, and the intake funnel and the throttle body are arranged along the down frame behind the down frame.

The intake funnel and the throttle body are arranged along the down frame behind the down frame, so that a space around the intake funnel is limited. Therefore, it is difficult to attach the resonator to the surroundings of the intake funnel without changing the shape of the down frame.

The above-mentioned configuration causes the resonator to be arranged in the air cleaner, so that it is possible to improve the noise reduction without changing the shape of the down frame and the like.

Other features, elements, characteristics, and advantages of the present invention will become more apparent from the following description of preferred embodiments of the present invention with reference to the attached drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

FIG. **1** is a side view of one side of a motorcycle according to one embodiment of the present invention;

FIG. **2** is a plan view showing a front portion of a vehicle body frame of FIG. **1**;

FIG. **3** is a partially enlarged side view of the motorcycle mainly showing an intake noise reduction device;

FIG. **4** is a plan view showing a base being supported at a head pipe and a pair of main frames;

FIG. **5**A is a side view of a downstream duct of FIG. **3** as viewed from behind;

FIG. **5**B is a side view of the downstream duct of FIG. **3** as viewed from the left;

FIG. **6** is a plan view of the downstream duct being attached to the base of FIG. **4**;

FIG. **7** is an external perspective view of an upper cover and a pair of upstream ducts of FIG. **3** as obliquely viewed from behind and above;

FIG. **8** is a plan view showing the upper cover and a rear cover being attached to the base and the pair of upstream ducts being attached to the upper cover;

FIG. **9** is a longitudinal cross sectional view mainly showing an inner structure of an air cleaner and a throttle body;

FIG. **10** is an external perspective view of an element main body and a sealing portion of a filter element of FIG. **9**;

FIG. **11** is a bottom view of the element main body and the sealing portion of FIG. **10** as viewed from below;

FIG. **12** is a cross sectional view taken along the line B-B of FIG. **11**;

FIG. **13**A is a plan view of a frame of the filter element of FIG. **9**;

FIG. **13**B is a side view of the frame as viewed in a direction of an arrow K**1** of FIG. **13**A;

FIG. **14**A is a plan view of an element support member of FIG. **9**;

FIG. **14**B is a side view of the element support member as viewed in a direction of an arrow K**2** of FIG. **14**A;

FIG. **15** is a plan view showing the element support member, the filter element and the rear cover being attached to an upper surface of the base of FIG. **6**;

FIG. **16** is an external perspective view of a resonator of FIG. **9**;

FIGS. **17**A and **17**B are diagrams for explaining a method of attachment of the resonator to the element support member;

FIG. **18** is an external perspective view showing a positional relationship between the resonator and an intake funnel;

FIG. **19**A is a cross sectional view taken along the line A-A of FIG. **9**;

FIG. **19**B is a diagram showing an inner space of the throttle body as viewed in a direction of an arrow Q**1** of FIG. **9**;

FIGS. **20**A and **20**B are side views showing a downstream duct and an intake funnel used in a first modified example;

FIG. **21** is a longitudinal cross sectional view showing an intake noise reduction device according to the first modified example;

FIG. **22** is a longitudinal cross sectional view showing an intake noise reduction device according to a second modified example;

FIG. **23**A is a cross sectional view taken along the line C-C of FIG. **22**;

FIG. **23**B is a diagram showing an inner space of the throttle body as viewed in a direction of an arrow Q**2** of FIG. **22**;

FIG. **24** is a longitudinal cross sectional view showing an intake noise reduction device of a comparative example used in a noise reduction performance test;

FIG. **25** is a graph showing the results of the noise reduction performance test of the intake noise reduction device; and

FIG. **26** is a graph showing the measurement results of noise during acceleration travelling of the motorcycle.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

An intake noise reduction device and a straddle-type vehicle including the intake noise reduction device according to one embodiment of the present invention will be described below with reference to drawings. A motorcycle will be described below as one example of the straddle-type vehicle.

(1) Schematic Configuration of Motorcycle

FIG. **1** is a side view of one side of the motorcycle according to one embodiment of the present invention. In FIG. **1**, the motorcycle **100** standing up to be perpendicular to the road surface is shown. In FIG. **1** and part of subsequent given diagrams, a front-and-rear direction L, a width direction W and a top-and-bottom direction H of the motorcycle **100** are indicated by arrows.

In the following description, a direction in which the arrow is directed in the front-and-rear direction L is referred to as forward, and its opposite direction is referred to as rearward. Further, a direction in which the arrow is directed in the width direction W is referred to as leftward, and its opposite direction is referred to as rightward. Further, a direction in which the arrow is directed in the top-and-bottom direction H is referred to as upward, and its opposite direction is referred to as downward.

As shown in FIG. **1**, the motorcycle **100** includes a head pipe **1** and a vehicle body frame **10**. FIG. **2** is a plan view showing a front portion of the vehicle body frame **10** of FIG. **1**. As shown in FIGS. **1** and **2**, the vehicle body frame **10** includes a pair of left and right main frames **11**, one down frame **12**, a pair of left and right lower frames **13** and a sub-frame **14**.

The pair of main frames **11** obliquely extends rearward and downward from the head pipe **1** as shown in FIG. **1**. The rear ends of the main frames **11** are curved downward. The sub-frame **14** extends rearward from rear ends of upper portions of the pair of main frames **11**.

The one down frame **12** extends downward from a lower portion of the head pipe **1**. The lower end of the down frame **12** is branched into the left and right as shown in FIG. **2**. The pair of lower frames **13** is provided to extend rearward from left and right lower ends **12***b* of the down frame **12**. The rear ends of the pair of lower frames **13** are respectively connected to the lower ends of the pair of main frames **11** as shown in FIG. **1**.

As shown in FIG. **2**, a screw hole sh for fixing a base **51**, described below (FIGS. **3** and **4**), is formed in a rear portion of the head pipe **1**. Further, a pair of brackets br for fixing the base **51**, described below (FIGS. **3** and **4**), and a fuel tank **9**, described below (FIG. **1**), is provided at inner edges of the pair of main frames **11**.

As shown in FIG. **1**, a front fork **2** is provided at the head pipe **1** to be swingable leftward and rightward. A front wheel **21** is rotatably supported at the lower end of the front fork **2**. A handle **22** is attached to the upper end of the front fork **2**.

An engine **3** is provided in a lower portion of the pair of main frames **11**. An air cleaner **5** is supported by the head pipe **1** and the pair of main frames **11** at a position above the engine **3**. A throttle body **4** is attached to the engine **3**. An intake funnel **6** is provided to connect the throttle body **4** to the air cleaner **5**. A resonator **7** is provided inside of the air cleaner **5**.

In the present embodiment, the intake noise reduction device **200** is constituted by the throttle body **4**, the air cleaner **5**, the intake funnel **6** and the resonator **7**. In the intake noise reduction device **200**, intake noise of the engine **3** is mainly reduced by the resonator **7**. Details of the intake noise reduction device **200** will be described below.

In the motorcycle **100** of FIG. **1**, a side cover SC is provided to cover part of the intake noise reduction device **200** from outside in the width direction W. Further, a seat **8** is provided to extend rearward from a rear end of an upper portion of the air cleaner **5**. The fuel tank **9** is provided at a lower portion of the seat **8**. The seat **8** and the fuel tank **9** are supported at the pair of main frames **11** and the sub-frame **14**. A rear arm **15** is provided to extend rearward from a lower end of the pair of main frames **11**. A rear wheel **23** is rotatably supported at the rear end of the rear arm **15**. The rear wheel **23** is rotated by motive power generated by the engine **3**.

(2) Details of Intake Noise Reduction Device

FIG. **3** is a partially enlarged side view of the motorcycle **100** mainly showing the intake noise reduction device **200**. In FIG. **3**, the side cover SC of FIG. **1** is not shown. As indicated by a thick one-dot and dash line in FIG. **3**, the air cleaner **5** of the intake noise reduction device **200** includes the base **51**, a downstream duct **52**, an upper cover **53**, a rear cover **54**, an upstream duct **55** and a filter element **60**.

(2-1) Base

The base **51** is supported at the head pipe **1** and the pair of main frames **11**. FIG. **4** is a plan view showing the base **51** being supported at the head pipe **1** and the pair of main frames **11**.

As shown in FIG. **4**, the base **51** includes a main body **51***a* and a supporter **51***b*. The main body **51***a* is a plate-shape member of which a substantially trapezoidal opening **51***o* is formed in a center portion and arranged on the pair of main frames **11**. A projection **51***p* locally projecting forward is formed at a front portion of the center of the main body **51***a*. The projection **51***p* is attached to a rear portion of the head pipe **1** (a portion of the head pipe **1** in which the screw hole sh of FIG. **2** is formed) using a screw. Further, a fixing portion **51***x* for fixing the front end of the upper cover **53** of FIG. **3** is formed at the front portion of the center of the main body **51***a*. The fixing portion **51***x* is formed to project upward, and is formed such that a rectangular cross section extends in the front-and-rear direction L. The rear end of the fixing portion **51***x* is opened. A through hole h is formed in a substantially center portion of the fixing portion **51***x*.

Left and right outer edges of the main body **51***a* are positioned outward of outer edges of the pair of main frames **11** that overlaps with the main body **51***a*. On the one hand, left and right inner edges of the main body **51***a* forming the opening **51***o* substantially overlap with inner edges of the pair of main frames **11**. Further, a plurality (nine in the present example) of screw holes sh are formed in the main body **51***a* to surround the opening **51***o*.

The supporter **51***b* is integrally provided at a rear portion of the main body **51***a* and arranged between the pair of main frames **11**. The supporter **51***b* is attached to the pair of brackets br of FIG. **2** using screws.

(2-2) Downstream Duct and Intake Funnel

FIG. **5**A is a side view of the downstream duct **52** of FIG. **3** as viewed from behind, and FIG. **5**B is a side view of the downstream duct **52** of FIG. **3** as viewed from the left. As shown in FIGS. **5**A, **5**B, the downstream duct **52** has a duct main body **52**M and a flange portion **52**F. The duct main body **52**M has a substantially trapezoidal opening **52***o* at the upper end. The flange portion **52**F is formed at the upper end of the duct main body **52**M to surround the opening **52***o*. Further, a plurality of through holes h are formed in the flange portion **52**F. The plurality of through holes h of the flange portion **52**F correspond to the plurality of screw holes sh of the base **51** of FIG. **4**.

An inner space RS of the duct main body **52**M is used as a storage space for an intake passage of the engine **3** and the resonator **7** of FIG. **1**. The duct main body **52**M is formed such that the inner space RS gradually becomes narrower from above towards below.

The intake funnel **6** is integrally formed at the lower end of the duct main body **52**M. The intake funnel **6** has an upstream opening **6***a* at the upper end and a downstream opening **6***b* at the lower end. The upstream opening **6***a* is positioned in the inner space RS of the duct main body **52**M, and the downstream opening **6***b* is positioned below the duct main body **52**M. The intake funnel **6** forms the intake passage P**2** of the engine **3** of FIG. **1**.

The downstream duct **52** is attached to the base **51** of FIG. **4**. FIG. **6** is a plan view showing the downstream duct **52** being attached to the base **51** of FIG. **4**. As shown in FIG. **6**, the duct main body **52**M of the downstream duct **52** is fitted into the opening **51***o* of the base **51** from above. In this state, the flange portion **52**F is positioned on the main body **51***a* of the base **51** such that the plurality of through holes h of the flange portion **52**F overlap with the plurality of screw holes sh of the base **51** (FIG. **4**).

(2-3) Upstream Duct, Upper Cover and Rear Cover

Subsequently, the upper cover **53**, the rear cover **54** and the upstream duct **55** of FIG. **3** will be described. As shown in FIG. **3**, the upper cover **53** and the rear cover **54** are attached to upper portions of the base **51**. Further, the pair of upstream ducts **55** is attached to both left and right side portions of the upper cover **53**.

FIG. **7** is an external perspective view of the upper cover **53** and the pair of upstream ducts **55** of FIG. **3** as obliquely viewed from behind and above. FIG. **8** is a plan view showing the upper cover **53** and the rear cover **54** being attached to the base **51** and the pair of upstream ducts **55** being attached to the upper cover **53**.

The upper cover **53** is a plate-shape member made of metal or resin, for example, and is formed such that a substantially arched cross section extends in the front-and-rear direction L as shown in FIG. **7**. Attachment portions **53***t* for attaching the pair of upstream ducts **55** are formed at both left and right side portions of the upper cover **53**.

Each upstream duct **55** is a square pipe-shaped member made of resin that forms the intake passage P**1** of the engine **3** of FIG. **1**, and has respective first and second openings **55***a*, **55***b* at respective upstream and downstream ends. The downstream ends of the pair of upstream ducts **55** are respectively attached to the left and right attachment portions **53***t* of the upper cover **53**. The pair of upstream ducts **55** is curved outward in the width direction W and forward from the downstream ends towards the upstream ends.

As shown in FIG. **8**, the upper cover **53** is attached to the upper surface of the base **51**, and the rear cover **54** is attached to the base **51** behind the upper cover **53**. Thus, a space covered by the upper cover **53** and the rear cover **54** (hereinafter referred to as an element storage space) ES is formed above the base **51**.

During the travelling of the motorcycle **100** of FIG. **1**, air outside of the air cleaner **5** flows into the intake passage P**1** through the first opening **55***a* of each upstream duct **55** as indicated by solid outlined arrows in FIGS. **3** and **8**. Further, the air that has flowed into the intake passages P**1** flows into the element storage space ES through the second opening **55***b* of each upstream duct **55** as indicated by dotted outlined arrows in FIGS. **3** and **8**.

FIG. **9** is a longitudinal cross sectional view mainly showing an inner structure of the air cleaner **5** and the throttle body **4**. In FIG. **9**, a longitudinal cross sectional view of the air cleaner **5** and the throttle body **4** being cut along a vertical plane passing through the center of the motorcycle **100** in the width direction W is shown. Further, in FIG. **9**, part of the engine **3** is cut out. The upstream duct **55** of FIG. **8** is not shown.

As shown in FIG. **9**, an element support member **70** is attached to the upper surface of the base **51** with the flange portion **52**F of the downstream duct **52** sandwiched therebetween. A filter element **60** is attached to an upper portion of the element support member **70**. In this state, the filter element **60** is stored in the element storage space ES. Further, the resonator **7** is attached to a lower portion of the element support member **70**. In this state, the resonator **7** is stored in the inner space RS of the downstream duct **52**. Details of the filter element **60**, the element support member **70** and the resonator **7** will be described below.

The air that has flowed into the element storage space ES from each upstream duct **55** of FIG. **8** flows into the inner space RS of the downstream duct **52** after being cleaned by the filter element **60**. Further, the air in the inner space RS is led to an intake port **3***a* of the engine **3** through intake passages P**2**, P**3** formed by the intake funnel **6** and the throttle body **4**.

The throttle body **4** includes a flow path forming pipe **4***a*, a throttle valve **4***b*, an injector **4***c* and a valve actuator (not shown). In the throttle body **4**, a degree of an opening of the throttle valve **4***b* and an injection state of the fuel by the injector **4***c* are adjusted.

(2-4) Filter Element

As shown in FIG. **9**, the filter element **60** of the present example includes an element main body **61**, a sealing portion **62** and a frame **63**. In the present embodiment, the element main body **61** and the sealing portion **62** are formed of a porous material made of resin, for example. Further, the frame **63** is formed of resin. In the element main body **61** and the sealing portion **62**, oil or the like may be impregnated, or does not have to be impregnated.

FIG. **10** is an external perspective view of the element main body **61** and the sealing portion **62** of the filter element **60** of FIG. **9**. FIG. **11** is a bottom view of the element main body **61** and the sealing portion **62** of FIG. **10** as viewed from below. FIG. **12** is a cross sectional view taken along the line B-B of FIG. **11**.

As shown in FIGS. **10** and **11**, the element main body **61** is formed to be substantially trapezoidal similarly to the opening **52***o* of the downstream duct **52** of FIG. **6**. Further, as shown in FIG. **12**, the element main body **61** is curved from an outer edge to a center portion such that the center portion projects upward. A through hole **61***h* is formed in the center portion of the element main body **61**.

As shown in FIGS. **11** and **12**, the sealing portion **62** is formed to be strip-shaped to extend along the outer edge (the lower end) of the element main body **61**. The sealing portion **62** is bonded to the outer edge of the element main body **61** using an adhesive. An element opening **62***o* is formed by an inner periphery of the sealing portion **62**. A groove **62***g* is formed in an upper surface portion of the sealing portion **62** positioned inward of the outer edge of the element main body **61**.

FIG. **13**A is a plan view of the frame **63** of the filter element **60** of FIG. **9**, and FIG. **13**B is a side view of the frame **63** as viewed in a direction of an arrow K**1** of FIG. **13**A.

As shown in FIGS. **13**A, **13**B, the frame **63** includes an outer edge frame **63***a*, a plurality (eight in the present example) of inner frames **63***b* and a guide pipe **63***c*. The outer edge frame **63***a* is formed to draw a substantial trapezoid. The eight inner frames **63***b* are formed at equal angular intervals to extend inward of the outer edge frame **63***a* and upward from eight positions at the outer edge frame **63***a*. Inner ends of the eight inner frames **63***b* are connected to a lower portion of an outer peripheral surface of the guide pipe **63***c* extending in the top-and-bottom direction.

The frame **63** of FIGS. **13**A, **13**B is stored in an inner space of the element main body **61** through the element opening **62***o* of FIG. **11**. In this case, the lower end of the outer edge frame **63***a* of the frame **63** is fitted into the groove **62***g* of the sealing portion **62**. Further, an upper portion of the guide pipe **63***c* of the frame **63** is inserted into the through hole **61***h* of the element main body **61**. In this manner, the frame **63** is provided inside of the element main body **61**, so that the shape of the element main body **61** is kept constant.

(2-5) Element Support Member

FIG. **14**A is a plan view of the element support member **71** of FIG. **9**, and FIG. **14**B is a side view of the element support member **70** as viewed in a direction of an arrow K**2** of FIG. **14**A. As shown in FIGS. **14**A, **14**B, the element support member **70** includes an element supporter **71**, a flange portion **72**, a plurality (eight in the present example) of inner frames **73** and a fixing portion **74**. The element supporter **71** is formed to draw a substantial trapezoid. Further, the element supporter **71** is formed to have a constant width such that the outer edge frame **63***a* of FIGS. **13**A, **13**B can be supported from below by the element supporter **71**.

The flange portion **72** is formed to surround the element supporter **71**. A plurality of through holes h are formed in the flange portion **72**. The plurality of through holes h of the flange portion **72** correspond to the plurality of screw holes sh of the base **51** of FIG. **4**.

As shown in FIGS. **14**A, **14**B, the eight inner frames **73** are formed at equal angular intervals to extend inward of the element supporter **71** and upward from eight positions at the element supporter **71**. The inner ends of the eight inner frames **73** are connected to the fixing portion **74**. A screw hole sh extending in the top-and-bottom direction H is formed in a center portion of the fixing portion **74**.

At part of the inner frame **73** (six in the present example) of the eight inner frames **73**, rivet pins **79** are respectively formed at portions spaced apart from an inner edge of the element supporter **71** by a predetermined distance. Each rivet pin **79** is formed to extend downward from each inner frame **73**. Details of the rivet pin **79** will be described below.

The filter element **60** is placed on an upper portion of the above-mentioned element support member **70**, and a wing screw WB (see FIG. **9**, and FIG. **15** that is described below) is attached to the screw hole sh of the fixing portion **74** of FIGS. **14**A, **14**B through the guide pipe **63***c* of FIGS. **13**A, **13**B. Further, the flange portion **72** of the element support member **70** is placed on the flange portion **52**F of the downstream duct **52** of FIG. **6**. In this state, screws are respectively attached to the plurality of screw holes sh of the base **51** of FIG. **4** through the plurality of through holes h of the downstream duct **52** and element support member **70**.

FIG. **15** is a plan view showing the element support member **70**, the filter element **60** and the rear cover **54** being attached to the upper surface of the base **51** of FIG. **6**. The element support member **70** and the filter element **60** are attached to the upper surface of the base **51** as described above, so that the opening **52***o* of the downstream duct **52** of FIG. **6** is closed by the filter element **60** as shown in FIG. **15**. Thus, air that is not cleaned by the filter element **60** is prevented from entering the downstream duct **52**.

In the element support member **70**, a metal mesh may be provided to cover an inner region of the element supporter **71**. Thus, foreign matters such as small stones are prevented from entering the downstream duct **52**.

(2-6) Resonator

FIG. **16** is an external perspective view of the resonator **7** of FIG. **9**. As shown in FIG. **16**, the resonator **7** has a chamber portion **110** and a pipe portion **120** that are integrally formed. Further, the chamber portion **110** has a spherical chamber **110**A, a plate-shape member **130** and a supporter **140**.

The pipe portion **120** is provided to extend downward from the lower end of the chamber **110**A. An inner space of the chamber **110**A and an inner space of the pipe portion **120** communicate with each other. The lower end of the pipe portion **120** constitutes an opening end **121** opened to the outside of the chamber **110**A and pipe portion **120**. A pair of projections **111** is formed to project to one side and the opposite side from a lower portion of the chamber **110**A to an upper portion of the pipe portion **120**.

The measurements of the chamber **110**A and pipe portion **120** are set to correspond to a frequency of the noise to be reduced (the intake noise of the engine **3**). In the present example, the measurements of the chamber **110**A and pipe portion **120** are set such that the intake noise of about 250 Hz to about 350 Hz is reduced, that is, the measurements of the chamber **110**A and pipe portion **120** are set such that a resonant frequency of the resonator **7** coincides with the frequency of the intake noise.

The plate-shape member **130** is provided above the chamber **110**A and is provided to intersect with an extending line LL of a central axis of the pipe portion **120**. The supporter **140** is provided to extend upward from the chamber **110**A and supports the plate-shape member **130** at a position above the chamber **110**A. Six through holes **131** respectively corresponding to the six rivet pins **79** of FIG. **14**A are formed in the plate-shape member **130**.

As described above, the resonator **7** is attached to the element support member **70** of FIGS. **14**A, **14**B. FIGS. **17**A, **17**B are diagrams for explaining a method of attachment of the resonator **7** to the element support member **70**.

A side view of the element support member **70** and the resonator **7** is shown in FIG. **17**A. As indicated by a thick solid arrow in FIG. **17**A, when the resonator **7** is attached to the element support member **70**, each rivet pin **79** extending downward from the element support member **70** is inserted into the corresponding through hole **131** of the resonator **7**. Thereafter, a portion, of each rivet pin **79**, projecting downward from the plate-shape member **130** is melted by ultrasonic caulking. Thus, the plate-member **130** of the resonator **7** is fixed to the plurality of inner frames **73** of the element support member **70**.

In FIG. **17**B, a bottom view of the element support member **70** to which the resonator **7** is attached as viewed from below is shown. As shown in FIG. **17**B, with the resonator **7** being attached to the element support member **70**, an opening that constitutes part of the intake passage is formed between an outer edge of the plate-shape member **130** and the inner edge of the element supporter **71**. This opening area is sufficiently larger than an opening area, described below, in the intake passage P3 of the throttle body **4**.

As described above using FIG. **15**, the element support member **70** of FIG. **17**B is attached to the upper surface of the base **51** of FIG. **6**. Thus, as shown in FIG. **9**, the resonator **7** is stored in the inner space RS of the downstream duct **52** while being supported at the element support member **70**.

A positional relationship between the resonator **7** and the intake funnel **6** will be described. FIG. **18** is an external perspective view showing the positional relationship between the resonator **7** and the intake funnel **6**. The resonator **7** is stored in the inner space RS of FIG. **9** while being supported at the element support member **70**, so that the opening end **121** of the pipe portion **120** is inserted into the intake funnel **6** as shown in FIG. **18**. In this case, the opening end **121** of the pipe portion **120** can be brought close to the throttle body **4** of FIG. **9**. Thus, a reduction in intake noise of the engine **3** by the resonator **7** is improved.

If the support of the resonator **7** comes off, the chamber **110**A of the resonator **7** falls towards the upstream opening **6***a* of the intake funnel **6**. Even in such a case, lower edges of the projections **111** of the present example are formed to project outward of the upstream opening **6***a*. Thus, the projections **111** of the resonator **7** that has fallen are caught by the upstream opening **6***a* of the intake funnel **6**. Therefore, the chamber **110**A is prevented from closing the upstream opening **6***a* of the intake funnel **6**.

(2-7) Relationship between Cross Sectional Area of Intake Passage of Intake Funnel and Opening Area of Intake Passage of Throttle Body

FIG. **19**A is a cross sectional view taken along the line A-A of FIG. **9**, and FIG. **19**B is a diagram showing an inner space of the throttle body **4** as viewed in a direction of an arrow Q1 of FIG. **9**. In FIG. **19**A, a cross section of the intake passage

P2 is indicated by the dotted pattern. In FIG. **19**B, an inner peripheral surface of the flow path forming pipe **4***a* of FIG. **9** is indicated by a reference numeral **4***i*, and an opening P**3**A formed when the throttle valve **4***b* is opened is indicated by the dotted pattern.

In the intake noise reduction device **200** according to the present embodiment, the pipe portion **120** of the resonator **7** is inserted into the intake passage P**2** of the intake funnel **6** as described above. Therefore, as shown in FIG. **19**A, a cross sectional area of the intake passage P**2** is formed between an inner peripheral surface of the intake funnel **6** and an outer peripheral surface of the pipe portion **120** is smaller by a cross sectional area of the pipe portion **120** than the cross sectional area of the intake passage P**2** of when the pipe portion **120** is not inserted. In other words, the pipe portion **120** reduces the cross-sectional area of the intake passage P**2** by an amount corresponding to a cross-sectional area of the pipe portion **120**.

Whereas, in the throttle body **4**, the opening of the throttle valve **4***b* is adjusted according to an operation amount of an accelerator by a rider, for example. The rider opens the accelerator to the maximum, so that the throttle valve **4***b* is opened to a predetermined maximum throttle opening as shown in FIG. **19**B.

In this case, when the cross sectional area of the intake passage P**2** between the intake funnel **6** and the pipe portion **120** is smaller than the opening area of the intake passage P**3** of the throttle body **4** opened to the maximum throttle opening, a sufficient amount of air cannot be led to the engine **3**. Therefore, intake performance of the engine **3** is reduced.

Thus, in the present embodiment, the measurements of each constituent element are set such that a minimum value of the cross sectional area of the intake passage P**2** between the intake funnel **6** and the pipe portion **120** is not less than the opening area of the intake passage P**3** of the throttle body **4** opened to the maximum throttle opening.

(3) Effects

In the above-mentioned intake noise reduction device **200**, because the opening end **121** of the pipe portion **120** of the resonator **7** is inserted into the intake funnel **6**, the opening end **121** of the pipe portion **120** of the resonator **7** is positioned close to the intake passage P**3** of the throttle body **4**. That is, the opening end **121** is positioned closer to the intake passage P**3** of the throttle body **4** than the upstream opening **6***a*. Thus, a reduction in intake noise of the engine **3** is improved. Further, because the resonator **7** is arranged in the inner space RS of the downstream duct **52**, limitation of the layout and design of surroundings of the intake funnel **6** by the presence of the resonator **7** is prevented.

Further, as described above, the cross sectional area of the intake passage P**2** formed between the inner peripheral surface of the intake funnel **6** and the outer peripheral surface of the pipe portion **120** is set to not less than the opening area of the intake passage P**3** of the throttle body **4**. Thus, an intake amount in the intake passage P**3** of the throttle body **4** is not limited by the pipe portion **120** of the resonator **7** inserted into the intake funnel **6**. Therefore, a reduction in intake performance of the engine **3** is prevented.

As a result, a reduction in intake noise of the engine **3** can be improved without the limitation of the layout and design of the surroundings of an intake system.

Further, the above-mentioned configuration enables a space located at a position further downstream than the filter element **60** inside of the air cleaner **5** to be effectively utilized by the resonator **7**, whereby it is possible to improve the noise reduction without increasing the size of the air cleaner **5**. Further, it is not necessary to provide a member for preventing deformation and damage of the resonator **7** in the surroundings of the intake system. Therefore, an increase in number of components is inhibited.

As described above, the resonator **7** has the plate-shape member **130**. The plate-shape member **130** is provided to close part of the inner space RS below the base **51**. In this case, the intake noise leaking to the inner space RS of the downstream duct **52** through the throttle body **4** and the intake funnel **6** from the engine **3** is reduced by the plate-shape member **130**. Thus, a reduction in intake noise can be more sufficiently improved. Further, the plate-shape member **130** functions as an attachment portion for attaching the resonator **7** to the element support member **70** and a noise reduction member. Therefore, an increase in number of components is inhibited.

In the above-mentioned motorcycle **100**, the downstream duct **52** is attached to the base **51**, and the lower end of the intake funnel **6** is connected to the throttle body **4**. The downstream duct **52**, the intake funnel **6** and the throttle body **4** are arranged along the down frame **12** behind the down frame **12**. In this manner, even when a space around the intake funnel **6** is limited, the resonator **7** is stored in the downstream duct **52**, so that it is possible to improve the noise reduction without changing the shape of the down frame **12**.

(4) First Modified Example

The intake noise reduction device **200** may include a downstream duct and an intake funnel that are described below instead of the downstream duct **52** and the intake funnel **6** of FIGS. **5**A, **5**B.

FIGS. **20**A, **20**B are side views showing the downstream duct and the intake funnel used in the first modified example. The side view of a downstream duct **152** used in the first modified example as viewed in one direction (rearward) is shown in FIG. **20**A, and the side view of the downstream duct **152** used in the first modified example as viewed in another direction (leftward) is shown in FIG. **20**B. The side views of FIGS. **20**A, **20**B respectively correspond to the side views of FIGS. **5**A, **5**B.

As shown in FIGS. **20**A, **20**B, in an intake funnel **106** of the present example, a ratio of an opening area of an upstream opening **106***a* to an opening area of a downstream opening **106***b* is set larger than a ratio of the opening area of the upstream opening **6***a* to the opening area of the downstream opening **6***b* of the intake funnel **6** of FIGS. **5**A, **5**B. Further, the opening area of the downstream opening **106***b* of the intake funnel **106** is set larger than the opening area of downstream opening **6***b* of the intake funnel **6** of FIGS. **5**A, **5**B. Further, in the intake funnel **106** of the present example, a boundary portion between the downstream duct **152** and the intake funnel **106** is formed to be smooth. The intake funnel **106** and downstream duct **152** may be integrally formed so that the boundary therebetween is smooth. In some embodiments, the intake funnel **106** is formed so that the intake funnel **106** is in direct contact with the downstream duct **152**.

Thus, an amount of air that can be led to the engine **3** by the intake funnel **106** is larger than an amount of air that can be led to the engine **3** by the intake funnel **6** of FIGS. **5**A, **5**B. In FIG. **20**A, the upper end of the intake funnel **106** is indicated by a dotted line such that the boundary portion between the downstream duct **152** and the intake funnel **106** can be clearly identified. Further, in FIG. **20**B, the intake funnel **106** is surrounded by a one-dot and dash line.

FIG. **21** is a longitudinal cross sectional view showing the intake noise reduction device **200** according to the first modified example. The intake noise reduction device **200** of FIG. **21** includes the downstream duct **152** and the intake funnel **106** of FIGS. **20**A, **20**B. In FIG. **21**, the intake funnel **106** is surrounded by a one-dot and dash line similarly to the example of FIG. **20**B.

Even in the first modified example, the resonator **7** is stored in the inner space RS of the downstream duct **152**. The opening end **121** of the pipe portion **120** of the resonator **7** is inserted into the intake funnel **106**. Further, a cross sectional area of the intake passage P**2** formed between the intake funnel **106** and the pipe portion **120** is set to not less than the opening area of the intake passage P**3** of the throttle body **4**. Thus, a reduction in intake noise of the engine **3** can be improved without limitation of the layout and design of the surroundings of the intake system.

(5) Second Modified Example

As described above, in the intake noise reduction device **200** according to the embodiments of the present invention, the measurements of each constituent element are set such that the cross sectional area of the intake passage P**2** formed between the intake funnel **6** and the pipe portion **120** is not less than the opening area of the intake passage P**3** of the throttle body **4**.

In the configuration of the intake noise reduction device **200** of FIG. **9**, when the maximum throttle opening is set large, the cross sectional area of the intake passage P**2** between the intake funnel **6** and the pipe portion **120** may be smaller than the opening area of the intake passage P**3** of the throttle body **4**. Therefore, a configuration in which an inner diameter of a portion, of the intake funnel **6**, into which the pipe portion **120** of the resonator **7** is inserted is increased is considered.

FIG. **22** is a longitudinal cross sectional view showing an intake noise reduction device **200** according to the second modified example. An intake funnel **206** provided in the intake noise reduction device **200** of FIG. **22** is set such that the inner diameter of the portion into which the pipe portion **120** of the resonator **7** is inserted is sufficiently larger than the intake funnel **6** of FIGS. **5**A, **5**B.

FIG. **23**A is a cross sectional view taken along the line C-C of FIG. **22**, and FIG. **23**B is a diagram showing an inner space of the throttle body **4** as viewed in a direction of an arrow Q2 of FIG. **22**. In FIG. **23**A, a cross section of the intake passage P**2** is indicated by the dotted pattern. In FIG. **23**B, an inner peripheral surface of the flow path forming pipe **4***a* of FIG. **22** is indicated by a numeral reference **4***i*, and an opening P3A formed when the throttle valve **4***b* is opened is indicated by the dotted pattern.

As shown in FIG. **23**A, a cross sectional area of the intake passage P**2** between the intake funnel **206** and the pipe portion **120** of the present example is sufficiently larger than the cross sectional area of the intake passage P**2** between the intake funnel **6** and the pipe portion **120** of FIG. **19**A. In this case, as shown in FIG. **23**B, even when the throttle valve **4***b* is fully opened, the cross sectional area of the intake passage P**2** between the intake funnel **206** and the pipe portion **120** is not less than the opening area of the intake passage P**3** of the throttle body **4**. Thus, even when the maximum throttle opening is equal to the throttle valve **4***b* being fully opened, a reduction in intake performance of the engine **3** is prevented.

(6) Noise Reduction Performance Test of Intake Noise Reduction Device

The inventor of the present application performed the noise reduction performance test regarding the intake noise reduction device **200** of FIG. **9**. Specifically, the inventor of the present application installed a microphone near an intake valve of the engine **3** connected to the intake noise reduction device **200** of FIG. **9**, and installed a microphone near the first opening **55***a* of the air cleaner **5** (FIG. **7**). Further, the inventor of the present application calculated a gain of amplitude of test noise in the first opening **55***a* (FIG. **7**) with respect to amplitude of the test noise in the engine **3** based on noise signals acquired by the two microphones with the throttle valve **4***b* being kept opened to the maximum throttle opening. The test noise includes the noise of a frequency of about 300 Hz equivalent to the above-mentioned intake noise.

Further, the inventor of the present application performed the noise reduction performance test similar to the above-mentioned example regarding the configuration in which the resonator **7** was removed from the intake noise reduction device **200** of FIG. **9**. Further, the inventor of the present application performed a noise reduction performance test similar to the above-mentioned example regarding an intake noise reduction device of a comparative example described below.

FIG. **24** is a longitudinal cross sectional view showing the intake noise reduction device of the comparative example used in the noise reduction performance test. As shown in FIG. **24**, the configuration of the intake noise reduction device of the comparative example is equal to the configuration of the intake noise reduction device **200** of FIG. **9** except for a configuration and arrangement of a resonator **7**X stored in the inner space RS of the downstream duct **52**.

The resonator **7**X has a chamber **180** and a pipe portion **190**. The chamber **180** has a substantially rectangular parallelepiped shape, and the pipe portion **190** is formed to obliquely extend downward from the lower end of the chamber **180**. An opening end **191** is formed at the lower end of the pipe portion **190**. The opening end **191** of the pipe portion **190** is not inserted into the intake funnel **6**. The measurements of the resonator **7**X are set such that a resonant frequency of the resonator **7**X is equal to the resonant frequency of the resonator **7** of FIG. **9**.

FIG. **25** is a graph showing the results of the noise reduction performance test of the intake noise reduction device. The ordinate of FIG. **25** indicates the gain of amplitude of the noise, and the abscissa indicates the frequency. Further, a thick solid line in the graph indicates the result of the noise reduction performance test regarding the intake noise reduction device **200** of FIG. **9**, a thick dotted line indicates the result of the noise reduction performance test regarding the configuration in which the resonator **7** is removed from the intake noise reduction device **200** of FIG. **9**, and a thick one-dot and dash line indicates the result of the noise reduction performance test regarding the intake noise reduction device of FIG. **24**.

In the graph of FIG. **25**, when the gain of amplitude of the noise indicates a positive value, it indicates that the noise transmitted from the engine **3** to the first opening **55***a* is amplified. Further, it indicates that the larger a value of the gain of amplitude of the noise is, the larger a degree of amplitude of the noise is. In this case, noise leaking from the intake noise reduction device **200** is increased.

On the one hand, when the gain of amplitude of the noise indicates a negative value, it indicates that the noise transmitted from the engine **3** to the first opening **55***a* is attenuated. Further, it indicates that the larger a value of the gain of amplitude of the noise is, the larger a degree of attenuation of the noise is. In this case, the noise leaking from the intake noise reduction device **200** is reduced.

According to the results of the noise reduction performance test of FIG. **25**, the gain of amplitude of the test noise regarding the intake noise reduction device **200** of FIG. **9** indicates a negative value and markedly reduced at the frequency of the intake noise (about 300 Hz). Thus, it is found that the intake noise transmitted from the engine **3** to the first opening **55***a* is largely attenuated.

On the one hand, the gains of amplitude of the test noise regarding the configuration in which the resonator **7** is removed from the intake noise reduction device **200** of FIG. **9** and the intake noise reduction device of FIG. **24** indicate positive values and increased at the frequency of the intake noise (about 300 Hz). Thus, it is found that the intake noise transmitted from the engine **3** to the first opening **55***a* is largely amplified.

As a result, it was confirmed that the intake noise reduction device **200** of FIG. **9** caused the noise having the similar frequency to the intake noise to be sufficiently reduced by the resonator **7** and the intake noise leaking from the air cleaner **5** to be sufficiently reduced.

(7) Noise Test of Motorcycle

The inventor of the present application measured noise during acceleration travelling of the motorcycle **100** of FIG. **1**. Specifically, the inventor of the present application measured the level of noise pressure of the noise generated from the motorcycle **100** during a period in which a vehicle speed reached a predetermined second speed (60 km/h, for example) from a predetermined first speed (30 km/h, for example) with the accelerator being opened to the maximum.

Further, the inventor of the present invention removed the resonator **7** from the motorcycle **100** of FIG. **1**, and measured the level of noise pressure of the noise generated from the motorcycle **100** from which the resonator **7** was removed by the similar steps to the above-mentioned example.

FIG. **26** is a graph showing the measurement results of the noise during the acceleration travelling of the motorcycle **100**. The ordinate of FIG. **26** indicates the noise pressure, and the abscissa indicates the frequency. Further, a thick solid line in the graph indicates the level of noise pressure of the noise generated from the motorcycle **100** of FIG. **1**, and a thick dotted line indicates the level of noise pressure of the noise generated from the motorcycle **100** from which the resonator **7** is removed.

As described above, in the motorcycle **100** from which the resonator **7** is removed, the intake noise is hardly reduced. Therefore, as shown in FIG. **26**, the level of noise pressure is markedly increased in a range of 250 Hz to 400 Hz that includes the frequency of the intake noise. On the one hand, in the motorcycle **100** of FIG. **1**, the level of noise pressure of the noise is sufficiently reduced in the range of 250 Hz to 400 Hz.

The inventor of the present application further measured the noise generated from the above-mentioned motorcycle **100** during the acceleration travelling (acceleration travelling noise). As a result, the acceleration travelling noise of the motorcycle **100** of FIG. **1** including the resonator **7** was lower than the acceleration travelling noise of the motorcycle **100** from which the resonator **7** was removed. The difference between the acceleration travelling noise of the motorcycle **100** of FIG. **1** including the resonator **7** and the acceleration travelling noise of the motorcycle **100** from which the resonator **7** was removed was about 3 dB.

In this manner, it was confirmed that the noise generated from the motorcycle **100** was sufficiently reduced when the intake noise reduction device **200** including the resonator **7** was provided in the motorcycle **100**.

(8) Acceleration Performance of Motorcycle

The inventor of the present application measured a distance by which the motorcycle **100** advanced in the period in which the vehicle speed reached the second speed from the first speed at a time of measurement of the noise during the above-mentioned acceleration travelling of the motorcycle **100** in order to confirm whether the acceleration performance of the motorcycle **100** was reduced by the resonator **7**. In this case, the shorter the measured distance is, the higher the acceleration performance of the motorcycle **100** is, and the longer the measured distance is, the lower the acceleration performance of the motorcycle **100** is.

As a result of the measurement of the advanced distance of the motorcycle **100**, the measured distance regarding the motorcycle **100** of FIG. **1** was equal to the distance measured regarding the motorcycle **100** from which the resonator **7** was removed. In this manner, in the motorcycle **100** of FIG. **1**, a reduction in acceleration performance due to the resonator **7** was not found.

(9) Output Characteristics of Engine

The inventor of the present application performed a test, described below, in order to confirm whether the output characteristics of the engine **3** were reduced by the resonator **7**.

The inventor of the present application measured the output of the engine **3** of when the throttle valve **4***b* was opened to the maximum throttle opening in the configuration in which the throttle body **4** and the engine **3** were connected to the intake noise reduction device **200** of FIG. **9** by a dynamometer. Further, the inventor of the present application removed the resonator **7** from the intake noise reduction device **200** of FIG. **9** and measured again the output of the engine **3** of when the throttle valve **4***b* was opened to the maximum throttle opening by the dynamometer.

The result of measurement of the output of the engine **3** of when the intake noise reduction device **200** including the resonator **7** was used was substantially equal to the result of measurement of the output of the engine **3** of when the intake noise reduction device **200** from which the resonator **7** was removed was used. In this manner, the output of the engine **3** was constant regardless of presence or absence of the resonator **7**. That is, it was confirmed that the output performance of the engine **3** was not reduced due to the resonator **7**. As a result, it is found that the intake performance of the engine **3** is not reduced due to the resonator **7**.

(10) Other Embodiments

(10-1) In the above-mentioned embodiments, each resonator **7** used in the intake noise reduction device **200** of FIGS. **9**, **21**, **22** includes the spherical chamber **110**A and the pipe portion **120** having a circular cross section. The chamber **110**A of the resonator **7** may have a rectangular parallelepiped shape instead of a spherical shape. Further, the cross section of the pipe portion **120** may be oval or rectangular instead of circular.

(10-2) In the above-mentioned embodiments, the resonator **7** is attached to the lower portion of the element support member **70**. The resonator **7** may be attached to the duct main body **52**M of the downstream duct **52**, or the duct main body **152**M of the downstream duct **152**. It is not limited that the resonator **7** is attached to the element support member **70**. Further, the resonator **7** does not have to have the plate-shape member **130**.

(10-3) While the above-mentioned embodiments are examples in which the present invention is applied to the motorcycle, the invention is not limited to this. The present invention may be applied to another straddle-type vehicle such as a motor tricycle, all-terrain vehicle (ATV), or the like.

(11) Correspondences Between Constituent Elements in Claims and Parts in Preferred Embodiments

In the following paragraphs, non-limiting examples of correspondences between various elements recited in the claims below and those described above with respect to various preferred embodiments of the present invention are explained.

In the above-mentioned embodiment, the engine **3** is an example of an engine, the intake noise reduction device **200** is an example of an intake noise reduction device, the air cleaner **5** is an example of an air cleaner, the intake funnels **6**, **106** are examples of an intake funnel, the upstream openings **6***a* of the intake funnel **6** and the upstream opening **106***a* of the intake funnels **106** are examples of an upstream opening, and the downstream opening **6***b* of the intake funnel **6** and the downstream opening **106***b* of the intake funnels **106** are examples of a downstream opening.

Further, the throttle body **4** is an example of a throttle body, the chamber portion **110** is an example of a chamber portion, the pipe portion **120** is an example of a pipe portion, the resonator **7** is an example of a resonator, and an opening end **121** of the pipe portion **120** is an example of an opening end.

Further, the filter element **60** is an example of a filter element, the base **51**, the upper cover **53** and the rear cover **54** are examples of a casing, the element support member **70** is an example of a support member, the plate-shape member **130** and the supporter **140** are examples of an attachment portion, and the plate-shape member **130** is an example of a plate-shape member.

Further, the projection **111** is an example of a projection, the rear wheel **23** is an example of a drive wheel, the motorcycle **100** is an example of a straddle-type vehicle, the head pipe **1** is an example of a head pipe, the main frame **11** is an example of a main frame, and the down frame **12** is an example of a down frame.

As each of constituent elements recited in the claims, various other elements having configurations or functions described in the claims can be also used.

While preferred embodiments of the present invention have been described above, it is to be understood that variations and modifications will be apparent to those skilled in the art without departing the scope and spirit of the present invention. The scope of the present invention, therefore, is to be determined solely by the following claims.

INDUSTRIAL APPLICABILITY

The present invention can be effectively utilized for mechanic structures having engines.

We claim:

1. An intake noise reduction device that leads air to an engine, comprising:
- an air cleaner;
- an intake funnel having an upstream opening positioned in the air cleaner;
- a throttle body provided between a downstream opening of the intake funnel and an intake port of the engine; and
- a resonator having a chamber portion and a pipe portion, the resonator being arranged in the air cleaner such that an opening end of the pipe portion is inserted into the intake funnel, and
- a cross-sectional area of a passage formed between an inner peripheral surface of the intake funnel and an outer peripheral surface of the pipe portion is set to be not less

than an opening area of an intake passage of the throttle body opened to a maximum throttle opening.

2. The intake noise reduction device according to claim **1**, wherein the air cleaner includes
- a filter element, and
- a casing that stores the filter element,
- wherein the intake noise reduction device further comprises a support member that supports the filter element on the casing at a position further upstream than the intake funnel, and
- further wherein the chamber portion of the resonator is provided at a position further downstream than the filter element.

3. The intake noise reduction device according to claim **2**, wherein the chamber portion of the resonator has an attachment portion attached to the support member.

4. The intake noise reduction device according to claim **3**, wherein the attachment portion includes a plate-shape member provided to close part of a space located at a position further downstream than the filter element.

5. The intake noise reduction device according to claim **1**, wherein the resonator has a projection projecting outward of the upstream opening of the intake funnel.

6. The intake noise reduction device according to claim **5**, wherein a lower edge of the projection is formed to extend outward from the pipe portion.

7. A straddle-type vehicle including:
- an engine;
- a drive wheel rotated by motive power generated by the engine; and
- an intake noise reduction device that leads air to the engine, including
  - an air cleaner,
  - an intake funnel having an upstream opening positioned in the air cleaner,
  - a throttle body provided between a downstream opening of the intake funnel and an intake port of the engine, and including an intake passage,
  - a resonator having a chamber portion and a pipe portion, the resonator being arranged in the air cleaner such that an opening end of the pipe portion is inserted into the intake funnel,
  - a connecting passage formed between an inner peripheral surface of the intake funnel and an outer peripheral surface of the pipe portion, the connecting passage having a cross-sectional area not less than an opening area of the intake passage of the throttle body opened to a maximum throttle opening.

8. The straddle-type vehicle according to claim **7**, further comprising:
- a head pipe;
- a main frame that extends in a rearward direction of the vehicle from the head pipe; and
- a down frame that obliquely extends rearward and downward from the head pipe at a position below the main frame, wherein
- the air cleaner is supported at a front portion of the main frame,
- the engine is held by the main frame at a position below the air cleaner, and
- the intake funnel and the throttle body are arranged along the down frame behind the down frame.

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